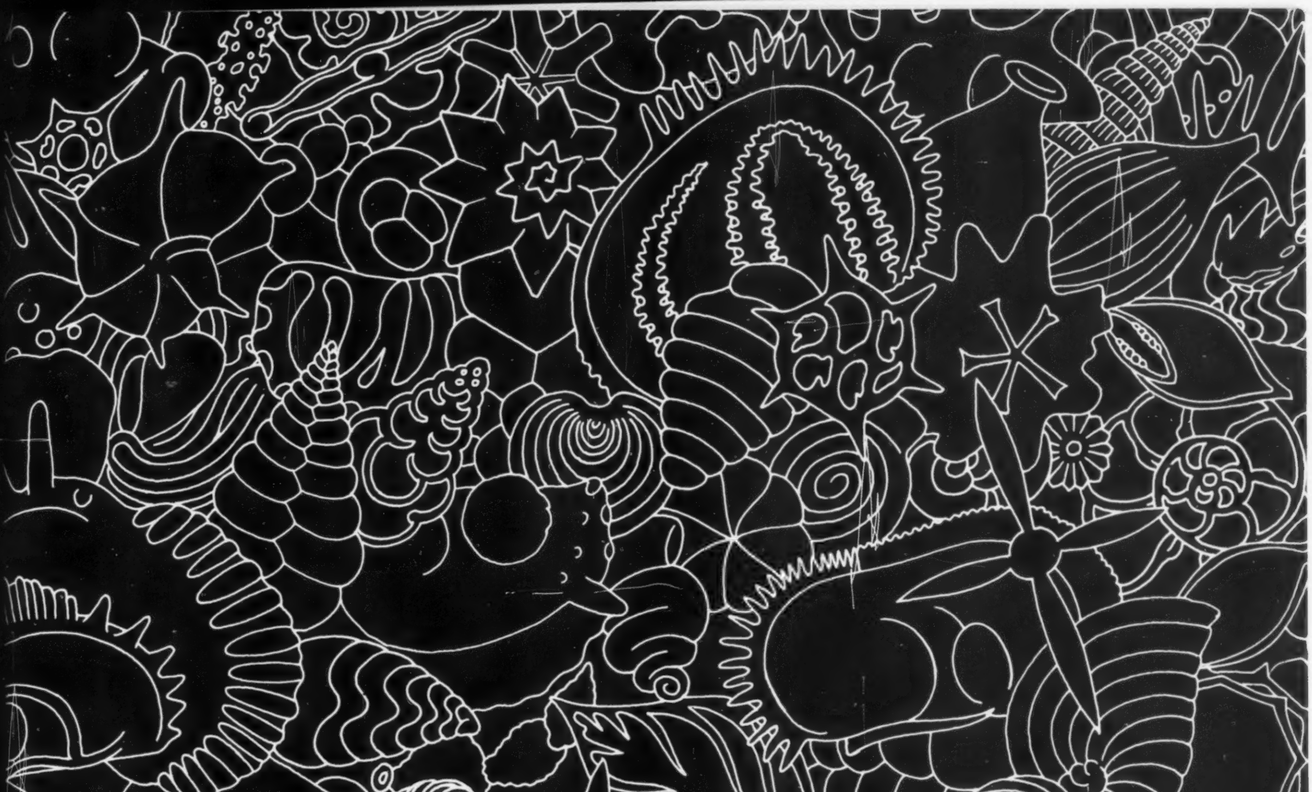


micro

PUBLISHED BY:

Department of Micropaleontology
American Museum of Natural History
Central Park West at Seventy-Ninth Street
New York 24, New York

micropaleontology

articles

news reports

The subscription price of this quarterly is $10.00 per year. Single copies are $3.00 each.

ABSTRACT: *The available stratigraphic and foraminiferal evidence from the Upper Cretaceous–Eocene succession of the various parts of the India-Pakistan-Burma region is presented; a synthesis of this evidence shows that there were four main cycles of deposition. Each cycle is shown to have started with a transgression and ended with a regress ion. Evidence of minor local regression is present in some places. The earliest of these cycles ended with the Maestrichtian, and this is taken to indicate the end of the Cretaceous period. The next cycle started with the Danian, which is now placed in the lowermost Tertiary (basal Paleocene), and continued into the Ranikot stage (Paleocene). The third and fourth cycles began with the Laki and the Khirthar stages, respectively, the two cycles together representing the whole of the Eocene.*

Foraminiferal biostratigraphy of the Cretaceous–Eocene succession in the India-Pakistan-Burma region

YEDATORE NAGAPPA
Assam Oil Company, Limited
Digboi, P. O., Assam, India

ACKNOWLEDGMENTS

The author is grateful to numerous colleagues, both in India and abroad, discussions with whom have resulted in the preparation of this paper. Particular mention must be made of Dr. Troelsen (Denmark), for sending foraminiferal residues from the type locality of the Danian; Dr. van Voorthuysen (Netherlands), for Upper Cretaceous and Paleocene material from the Netherlands; Drs. Glaessner (Australia) and van der Vlerk (Netherlands), for valuable information on the correlation of the Far East succession; and P. Evans, H. R. Tainsh, and A. J. Philipson, for kindly reading through the paper while it was in draft form and suggesting several improvements. K. N. Mehta assisted in checking some of the small foraminifera, and B. B. Bhattacharji was very helpful in checking and correcting the final draft. The illustrations were drawn by T. K. Singh. It is a pleasure to acknowledge the personal interest shown by Dr. M. S. Krishnan, Director of the Indian School of Mines and Applied Geology, and by W. B. Metre, Senior Geologist, Assam Oil Company, during the preparation of this paper. The paper is published with the kind permission of the Assam Oil Company, Limited.

INTRODUCTION

Common evolutionary trends in certain groups of foraminifera have been of considerable help in understanding and correlating the rocks of the Cretaceous–Eocene succession in various parts of the world. It is true that the biological history as recorded in the rocks of this period is by no means complete, and there are many gaps in our knowledge. Even so, a careful examination of the available fossil records has made it possible to compare reasonably well the stratigraphic relations of this part of the geologic sequence in several basins of the world. Recent investigations by Hiltermann, Grimsdale, Bolli, Gandolfi, Cita, and Reichel, to mention only a few, have shown examples of foraminifera exhibiting remarkably constant evolutionary trends in the Cretaceous–Paleocene rocks of Europe and America. Such investigations have recently been extended to the Middle East, notably by Smout, Henson, and workers in Egypt and Israel. The genera that have been helpful in stratigraphic palaeontology include *Bolivina*, *Bolivinoides*, *Globigerina*, *Globorotalia*, *Globotruncana*, *Guembelina*, *Neoflabellina*, and *Nummulites*.

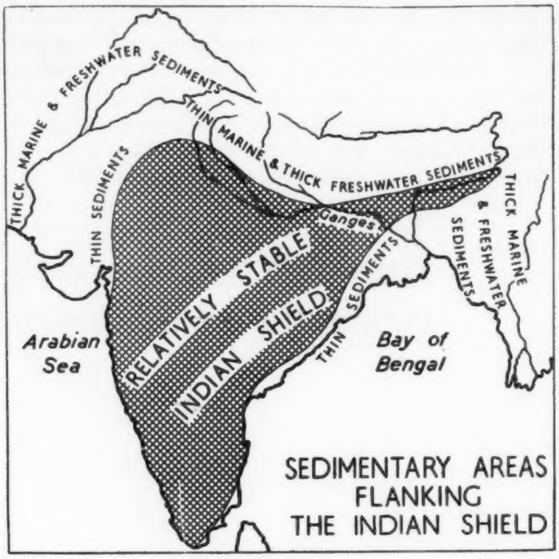
In *Globotruncana*, for example, the earliest forms occurring in the Cenomanian are of the single-keeled type (e.g., *Globotruncana appenninica* Renz and *Globotruncana stephani* Gandolfi). In the Turonian and lower Senonian, these forms are replaced by the double- and triple-keeled forms of the type of *Globotruncana linneiana* (d'Orbigny) and *Globotruncana lapparenti* Brotzen. In the upper Senonian, there is a reversion to the earlier single-keeled type represented by the group of *Globotruncana stuarti* (de Lapparent). *Globotruncana* is not known to have survived the Senonian.

In the case of *Globigerina*, large forms of the type of *Globigerina cretacea* d'Orbigny, with an umbilical aperture in each of the chambers, on the ventral side, are absent in rocks of Cenomanian age. This type makes its first appearance in the Turonian, and continues to occur throughout the Senonian. In the Danian this type is replaced by *Globigerina pseudobulloides* Plummer and *Globigerina triloculinoides* Plummer.

GEOGRAPHIC INDEX TO PLACE NAMES MENTIONED IN THE TEXT

Place name	*Latitude*	*Longitude*	*Map reference*
Bagh	22°21½′	74°47′	46 J/15
Bara Nala*	26°7′	67°54′	35 N/16
Bhamo* (second defile of the Irrawaddy)	24°15′	97°14′	92 H/3
Broach	21°41′	72°58′	46 C/14
Burzil	34°55′	75°5′	43 N/1
Chharat	33°35′	72°33′	43 C/10
Chantongia	26°33′	94°41′	83 J/10
Chikkim	32°21′	77°59½′	52 H/15
Damchara	25°1′	92°45′	83 C/12
Des Valley*	29°36′	68°28′	39 C/6
Dunghan Range*	29°52′	68°14′	39 C/1
Gaj River*	26°51′	67°10′	35 N/1
Gangaw	22°10′	94°8′	84 J/4
Ghalha	21°17¾′	73°2¼′	46 G/3
Harangajao	25°7′	92°51¾′	83 C/16
Hukawng Valley	–	–	92 B
Kampa Dzong	28°17′	88°32′	77 D/11
Kateru	17°2½′	81°46′	65 G/16
Khattan	29°34′	68°28½′	39 C/6
Kohat	33°36′	71°26′	38 O/6
Ladakh	34°0′	77°16′	52 G/5
Lhasa	29°39′	91°8′	77 O/2
Mehrab Tangi*	30°8′	67°59′	34 N/16
Nammal Gorge*	32°40′	71°48½′	38 P/14
Pangadi	17°1′	81°39′	65 G/12
Panoba	33°36½′	71°54′	38/O 14
Pondicherry	11°56′	79°50′	58 M/13
Prome	18°49′	95°13′	85 N/5
Quetta	30°12′	67°1′	34 N/4
Rajamahendri	17°½′	81°46′	65 G/16
Rajpipla	21°30′	73°2′	46 G/2 & 3
Rakhi Nala*	29°57½′	70°6′	39 K/1
Ramree Island	–	–	85 E/12 & 16
Samana Range*	30°33′	70°55′	38 K/14
Shekhan Nala*	33°35¾′	71°30¾′	38 O/10
Shigatse	29°16′	88°55′	77 C/15
Simla	31°6′	77°8′	53 E/4
Spiti Valley	–	–	52 L & 53 I
Surat	21°12′	72°50′	46 C/16
Tarkeswar	21°22½′	73°3¾′	46 G/3
Tarkhobi	33°35½′	71°50′	38 O/14
Taungup	18°52′	94°16′	85 J/5
Tilin	21°41½′	94°6′	84 K/2
Trichinopoly	10°49′	78°42′	58 J/9
Zinda Pir	30°25′	70°29′	39 J/7, 11

* Co-ordinates refer to points nearest to exposures examined.



TEXT-FIGURE 1

Other groups show similar changes in character that are all of considerable help in correlating rock sequences in widely separated areas. The remarkable nature of these changes is that they follow more or less the same sequence throughout the world. Glaessner (1945, pp. 206–207) remarks: "One of the most striking features of the upper Senonian foraminiferal fauna is its uniformity throughout the world." But this remark applies almost equally well to the whole of the Upper Cretaceous, forming one of the most important landmarks in the geologic history of many parts of the world. The common evolutionary characters exhibited by the faunal sequences afford a means of fairly accurate global correlation. In the present note, an endeavour is made to use all available records (published and unpublished) pertaining to the foraminiferal fauna of the Cretaceous–Eocene succession in the India-Pakistan-Burma region, in order to present a connected account of the faunal evolution of the period.

In Europe, the age of the Danian and its correlatives had created a very controversial problem (Muller and Schenck, 1943), mainly because of correlations based on insufficient evidence. The position has recently changed considerably, and the researches of Reiss (1954) and of Loeblich and Tappan (1957) in particular, together with those of several European palaeontologists, have now shown clearly that the most significant change in the faunas in the region of the Upper Cretaceous and basal Tertiary boundary takes place at the end of the Maestrichtian. In its type area, the Montian has the same foraminifera

as the Danian of Denmark, and a correlation of these beds with the Midway stage of North America is now an established fact. The top of the Maestrichtian has therefore been taken as representing the end of the Cretaceous period. The foraminiferal faunas of this period in the India-Pakistan-Burma subcontinent, as will be shown in the following account, show identical changes.

REGIONAL GEOLOGIC HISTORY

The disruption of the Gondwana continent, and the Himalayan orogeny that followed in its wake, had a profound influence on the Cretaceous–Eocene history of this subcontinent. The Gondwana continental facies was quite extensive, and stretched eastward from just south of the Kashmir syntaxis in the northwest, all along the southern border of the Himalayan Range, through Sikkim and into Assam. The Central Assam hill ranges (the Garo, Khasi, Jaintia and Mikir Hills) probably formed a part of this continent (see text-fig. 1). The marine (Tethyan) phase of the late Mesozoic–early Tertiary interval is well developed in the western parts of Sind-Baluchistan (the calcareous region of Vredenburg), from where it extends northeastward into the Potwar and the hill ranges bordering it (the Kala Chitta Range and the Salt Range). To the south and east, isolated exposures are also found in Rajasthan, in Cutch, and in the Cambay area. But the Cretaceous development in these areas is either poor or not present at all. To the north and east, the Tethyan facies probably continued all along the central Himalayan and Tibetan region. Assam and Arakan apparently formed a part of this same province in the early phase of this period, or at least there appears to have been no differentiation between the Tethyan and the Indo-Pacific provinces as revealed by the fossils. This differentiation, however, began soon after the Ranikot stage (Paleocene), when the Tethys sea gradually receded westward and perhaps northward as a result of progressive Himalayan orogeny, and by the end of the Eocene a complete separation seems to have been established.

Continuous geologic records are, however, limited to certain areas only, and, even there, very little is known of the Upper Jurassic to Lower Cretaceous transition. Information concerning the relatively inaccessible hilly parts of the region is meagre, and this applies particularly to the Himalayan region north of Uttar Pradesh and Bihar, as well as to Burma. It is hoped that the brief survey submitted in the present note will serve one important purpose, namely, to stimulate interest by indicating how little is known, so that in time we may come to know as much as there is to be known.

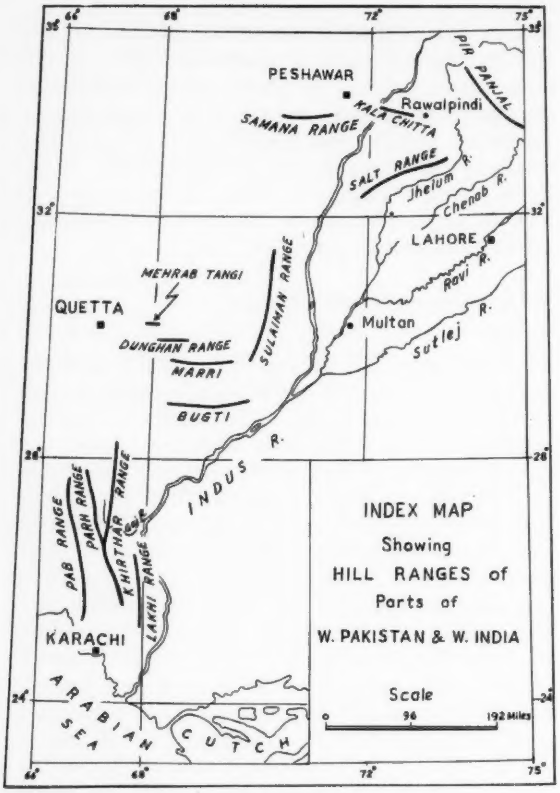
It appears convenient to start the present study from the Sind-Baluchistan area in the northwest, as this forms the type area for many of the established stratigraphic groups in the Cretaceous–Eocene succession, and to follow it eastward into Assam and finally into Burma. The coastal developments in the Trichinopoly-Pondicherry area on the east coast, and the small development in the Narbada Valley on the west, will be considered last.

THE BIOSTRATIGRAPHIC RECORD

Sind

The best succession of the Cretaceous–Eocene in Sind is found in the Lakhi Range (some of the important hill ranges in Sind-Baluchistan are shown in text-fig. 2), where the Bara Nala cuts across the range, exposing a continuous sequence of rocks from the Upper Cretaceous (Maestrichtian) to the Middle Eocene. Higher beds are also exposed, but for the purposes of this note it is not necessary to consider them. Blanford (1879, pp. 131–133) has given a detailed description of the Bara Dome succession, but unfortunately his section did not extend beyond the Laki limestone (his Khirthar limestone), which forms the highest ridges of the Lakhi Range. On the east flank he described "pale olive clays of Khirthar age" overlying the steeply dipping Laki limestone (Blanford, 1879, p. 132), but he apparently did not show this group separately in the section given in his plate 5. These beds are also of Laki age, and are here shown in text-figure 3, under the name Chat beds. Vredenburg (1909*a*) gave an excellent summary of the succession in Sind, and all of this information is incorporated in our Table 1, although the discussion that follows is mainly restricted to the Bara Dome sequence.

Table 1 shows two large, virtually unfossiliferous groups; one is the sandstone group immediately overlying the *Hemipneustes* beds, and the other is the lower Ranikot (including basal), overlying the *Cardita beaumonti* beds. The faunal picture in the region of the Cretaceous–Tertiary transition is therefore incomplete in this section (see text-fig. 4). The lowest beds in the section, the *Hemipneustes* beds, contain *Orbitoides media* d'Archiac, *Siderolites calcitrapoides* Lamarck, and *Omphalocyclus macropora* (Lamarck); the small foraminifera are difficult to determine in thin sections of the rock, as the limestone is very hard, but the few genera that could be determined include *Globigerina* and *Guembelina*. The fauna is typical of the Maestrichtian. *Globotruncana (Globotruncana linneiana* and *Globotruncana stuarti)* has been found in association with *Omphalocyclus* in the lower part. The megafauna consists of echinoids and



TEXT-FIGURE 2

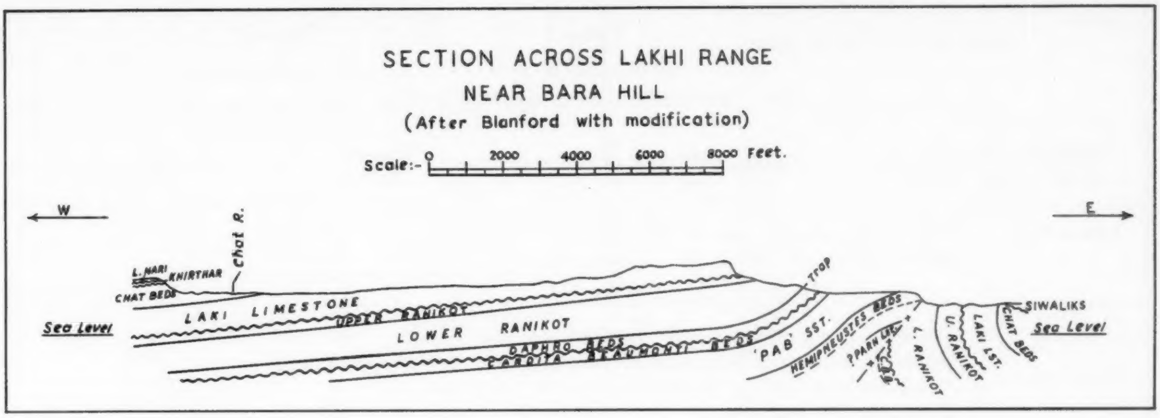
some mollusks, especially toward the top of the stage, where the limestone becomes progressively sandy before finally passing into the sandstone group above.

The sandstone group has been regarded as equivalent to the Pab sandstone. However, in the Pab Range, which is the type area, the Pab sandstone is overlain by a group of shales with a Maestrichtian fauna in the basal part, and is underlain by porcellanic limestone with the same type of fauna. The Pab sandstone, though varying in thickness considerably (from zero to over 2000 feet) and probably transgressing time planes, seems to be intercalated between strata with typical Maestrichtian fossils. In the Lakhi Range, the sandstone body shown in Table 1 lies wholly above the group of strata with Maestrichtian fossils, and the rocks overlying the sandstone body contain Danian fossils.

The next higher fossiliferous group is the *Cardita beaumonti* beds. The megafossils here consist mainly of corals and mollusks. The basal bed has yielded abundant specimens of *Nautilus*. The small foraminifera of the *Cardita beaumonti* beds are of special interest. In this fauna *Globotruncana* is absent; *Globorotalia* is also virtually absent, except for one occurrence. Abundant forms of *Globigerina* occur at certain horizons, the common species being *Globigerina pseudobulloides* and *Globigerina triloculinoides*. None of the common upper Senonian genera and species, such as *Globigerina cretacea*, *Globotruncana*, *Guembelina plummerae* Loetterle, *Neoflabellina*, *Pseudotextularia*, and *Ventilabrella*, is present in this fauna. At the same time, typical Paleocene larger foraminifera are also absent. This fauna compares reasonably well with that of the type Danian in Denmark, providing an independent check on the earlier age determination (Danian) for these beds.

Above the *Cardita beaumonti* beds there is, for the second time, a gap in the faunal sequence until the upper Ranikot is reached. Stray occurrences of a few arenaceous foraminifera have, however, been found in the lower Ranikot, suggesting that this group is not wholly of fluviatile origin. The upper Ranikot has yielded a rich fauna of mollusks, corals, foraminifera, and some algae; the larger foraminifera described from this group by Nuttall (1926*a*) and Davies (1927*a*) include the typical Paleocene genus *Ranikothalia*, together with *Lockhartia haimei* (Davies), *Discocyclina*, *Alveolina*, etc. The small foraminifera have not been thoroughly studied, but they include *Globorotalia* of the group of *Globorotalia velascoensis* (Cushman) in this area.

In the Laki limestone, which unconformably overlies the Ranikot in this section, there is an abundance of *Alveolina*, *Orbitolites complanatus* Lamarck, *Lockhartia*, *Dictyoconoides*, *Discocyclina*, simpler types of *Nummulites*, such as *Nummulites atacicus* Leymerie, and a few assilines. One of the common assilines occurring here was included by Nuttall (1925*a*, p. 441, pl. 26, figs. 1–2) under *Assilina granulosa* (d'Archiac). There are, however, considerable differences from the typical *Assilina granulosa*, and, since this form also occurs generally in beds above those containing typical *Assilina granulosa*, it seems desirable to separate it from that species. For convenience of reference, this form is here designated as *Assilina* sp. *A*. The same fauna continues into the Chat beds without appreciable change. Because the Laki limestone is hard, most of the fauna was studied in thin sections of the limestone, and it was therefore not possible to obtain a complete picture of the microfauna. The overlying Chat beds, being mainly argillaceous, have yielded a fairly rich foraminiferal fauna. Abundant mollusks and Ostracoda also occur. The small foraminiferal genera include *Ammobaculites*, *Anomalina*, *Bolivina*, *Cibicides*, *Discorbis*, *Eponides*, *Glomospira*, *Haplophragmoides*, *Lockhartia*, *Quinqueloculina*,



TEXT-FIGURE 3

lina, *Rotalia*, *Trochammina*, etc. At certain levels in the Chat beds there is a superabundance of *Dictyoconus indicus* Davies, the marly bands which constitute these levels being literally composed of nothing but these tests.

In the Khirthar, various forms of *Nummulites*, such as *Nummulites obtusus* (Sowerby) and *Nummulites acutus* (Sowerby), are present. The large form *Assilina papillata* Nuttall replaces the smaller and thinner *Assilina* sp. *A*. The discocyclines are also large and more robustly built, the common ones being *Discocyclina dispansa* (Sowerby) and *Discocyclina sowerbyi* Nuttall. But the full Khirthar sequence is not developed in the Lakhi Range, since most of it is cut out by the unconformities that are present both above and below this group.

The faunal sequence described above and the associated lithology suggest deposition on the continental shelf in warm, shallow, sometimes sheltered waters of the inner neritic environment. The sandstone group overlying the *Hemipneustes* beds, and the lower Ranikot beds (including the basal Ranikot), suggest two regressive phases, the older one being the main regression corresponding to the end of the Cretaceous cycle, and the other, following the deposition of the *Cardita beaumonti* beds, representing a minor event in the succeeding cycle. The Chat beds, with their associated gypsum and restricted though rich fauna, also appear to suggest another regression at the end of the Laki. The Khirthar, as elsewhere, represents a period of transgression, which brought with it a large variety of new species.

The succession elsewhere in Sind is much the same, with bits and pieces missing (see text-fig. 5, Meting-Jherruck). One other important section in Sind must be mentioned. This section lies along the Gaj River, the only river that cuts across the Khirthar Range, which forms the border between Sind and Baluchistan. A good succession extending from the Belemnite shale and Parh limestone group to the Khirthar and higher rocks is exposed in this section (Blanford, 1879). Unfortunately, the faunal sequence in this section is not known in sufficient detail.

Cutch

Before passing on to the very interesting area of Baluchistan, it seems convenient to mention here the development in Cutch. What appears to be a continuation of the Sind succession, at least insofar as the Khirthar, Nari, and Gaj are concerned, is found in the western and southern parts of Cutch (Wynne, 1872). These rocks overlie the Deccan Trap; the lowest beds above the trap, which consist of green shales with gypsum and also coal-bearing in places, are probably of Laki age. They contain *Assilina* sp. *A*. and *Nummulites* of Laki aspect. No foraminifera have so far been reported from the Cretaceous Bhuj series (Raj Nath, 1943). These rocks occur immediately below the trap in Cutch, but the lithology (mainly sandstones) does not appear to be of the type likely to contain foraminifera. The Khirthar rocks in the area consist of detrital limestones with abundant foraminiferal debris consisting of *Nummulites*, *Assilina*, *Alveolina*, *Linderina*, *Discocyclina*, etc. The succession is summarized in Table 2 (see also Arkell, 1956).

Baluchistan

In Baluchistan, two facies are developed (Vredenburg, 1909*b*). In the western part, a monotonous succession of shales and sandstones, attaining an enormous thickness toward the Mekran Coast, is found. The age of these rocks is mostly post-Eocene, though in the north some Eocene may have been

TABLE 1

SUCCESSION IN SIND

After Vredenburg (1909), with modifications.

Names of groups	*Lithology and fauna*	*Maximum thickness*		*Age*
Lower Nari	Limestones, shales, and sandstones, with *Nummulites fichteli*, *N. intermedius*, *Lepidocyclina*, etc.			OLIGOCENE
	--------- Unconformity ---------			
Khirthar	Massive, nodular limestones and subordinate shales, with *Nummulites perforatus*, *N. laevigatus*, *N. gizehensis*, *N. obtusus*, *Assilina exponens*, *A. spira*, *Discocyclina dispansa*, etc.	up to 1000′		Mostly MIDDLE EOCENE
	--------- Unconformity ---------			
Laki	Limestones, shales, calcareous shales, and gypseous shales, with alveolines, *Nummulites atacicus*, *Assilina granulosa* (only in Meting limestone), *Discocyclina ranikotensis*. At the base there is a lateritic bed.	up to 1750′		LOWER EOCENE
	--------- Unconformity ---------			
Ranikot	UPPER: Ferruginous sandstone, locally with some coal near Meting-Jherruck, brown foraminiferal limestones, calcareous shales, and impure sandstones, with *Miscellanea miscella*, *Lockhartia haimei*, *Ranikothalia nuttalli*, *R. sindensis*, *Discocyclina ranikotensis*, etc.	up to 800′		PALEOCENE
	LOWER: Soft sandstones, mudstones, and sandy shales, locally with some lignite. Unfossiliferous except for a few arenaceous foraminifera.	up to 1500′		
	TRAP: Weathered dark-brown or greenish-brown vesicular trap.	up to 70′		
	BASAL RANIKOT (Daphro beds): Mainly sandstones and argillaceous sandstones, similar to beds overlying the trap. No foraminifera.	about 180′		
Cardita beaumonti beds	Olive-green shales alternating with calcareous beds. The shales have small foraminifera, including *Globigerina pseudobulloides* and *G. triloculinoides*.	about 250′	Danian	Basal PALEOCENE
"Pab sandstone"	Mainly very hard sandstones, unfossiliferous, with two or three thin bands of trap locally developed.	870′	Maestrichtian	UPPER CRETACEOUS
Hemipneustes beds	Light-coloured massive or thick-bedded limestones, becoming sandy toward the top, with *Orbitoides media*, *Omphalocyclus macropora*, etc. Base not exposed.	320′+		

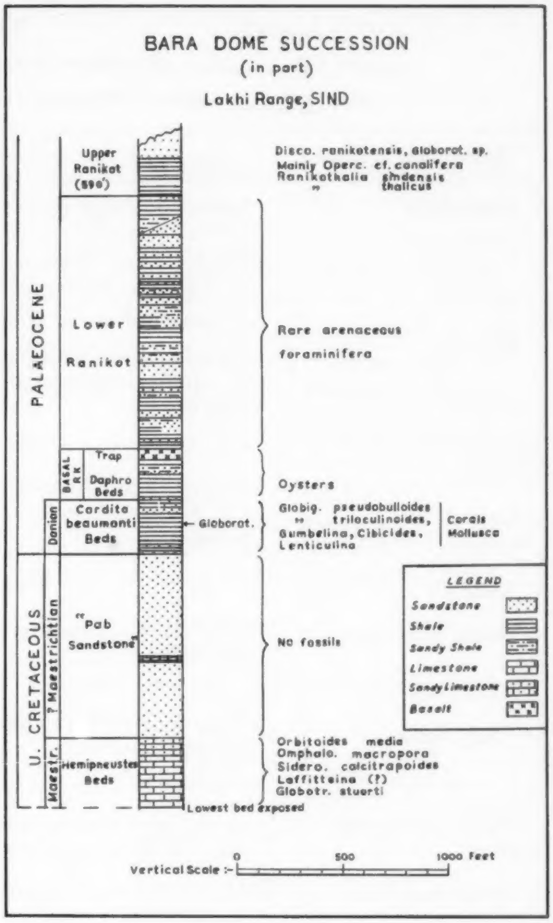
developed. To the east and south, in the autochthonous calcareous zone, the succession is often complicated by intense folding. In some cases, there is a monotonous development of rocks consisting of hard porcellanic limestones ranging in age from Lower Cretaceous to perhaps Oligocene and possibly even Lower Miocene. The generalized succession for this region, taken from Vredenburg but with slight modifications from later observations, is shown in Table 3. The fauna of the Belemnite shale

TABLE 2

SUCCESSION IN CUTCH

After Wynne (1872), Raj Nath (1942), and Arkell (1956) with modifications.

Stratigraphic divisions	*Lithology*	*Age*
Nummulitic group (300′)	Brown limestone, shale, and sandstone (60′)	OLIGOCENE (Lower Nari)
	Massive limestone (240′)	Mainly MIDDLE EOCENE (Khirthar)
Sub-Nummulitic group (50–100′)	Gypseous shales, carbonaceous in places, laterite	LOWER EOCENE (Laki)
	– – Unconformity – –	
Trap	Deccan Trap	(?) PALEOCENE or LOWER EOCENE
	– – Unconformity – –	
Bhuj series (Umia plant beds) (250′)	Mainly sandstones, with some sandy shales	LOWER CRETACEOUS (Aptian to Albian)
Ukra beds (100′)	Mainly calcareous shale	
Umia beds (excluding the Ammonite bed)	Unfossiliferous sandstones and shales	LOWER CRETACEOUS (?Neocomian)



TEXT-FIGURE 4

here is not clearly known, but in the rest of the Cretaceous succession the faunal sequence is fairly clear. *Globotruncana* is represented by simple, single-keeled species of the type of *Globotruncana appenninica* in the lower beds; these are followed by bi- and tri-carinate complex forms of the *Globotruncana lapparenti–Globotruncana linneiana* group, and finally, in the highest levels of the Parh limestone, a reversion takes place back to the single-keeled forms, this time of the *Globotruncana stuarti* group. Vredenburg's "*Lituola* beds" appear to be indistinguishable from the Parh limestone type of rocks, and have therefore been included in this group.

In the Pab Range, southern Las Bela, there is a thick group of shales overlying the Pab sandstone. Within this shale group a full faunal evolution from the Maestrichtian through the Danian into the Paleocene can be studied. The lithofacies appears to have been fairly constant throughout. Here the typical Maestrichtian forms, such as *Globotruncana stuarti* and *Guembelina striata* (Ehrenberg), which occur in the lower part, are replaced by *Globigerina triloculinoides* and *Globigerina pseudobulloides* (indicating the Danian) in the higher horizons. In this range *Globotruncana* is absent, and *Globorotalia* has been found in only a single sample (compare the *Cardita beaumonti* beds of Sind). Still higher, this fauna is supplemented by typical Paleocene forms belonging to the genera *Bulimina, Cibicides, Globigerina, Haplophragmoides, Trifarina, Uvigerina,* etc. It is interesting to note that in the whole range, from the base of the Upper Cretaceous to the Paleocene, larger foraminifera are not present at all. The limestones of this age that occur elsewhere are of fine-grained porcellanic type, suggesting that they probably accumulated as a fine calcareous mud similar to what is accumulating today in parts of the Persian Gulf. The entire fauna suggests an open-sea environment and probably deeper water than was represented

Table 3

Succession in southern Baluchistan

After Vredenburg (1909), with modifications.

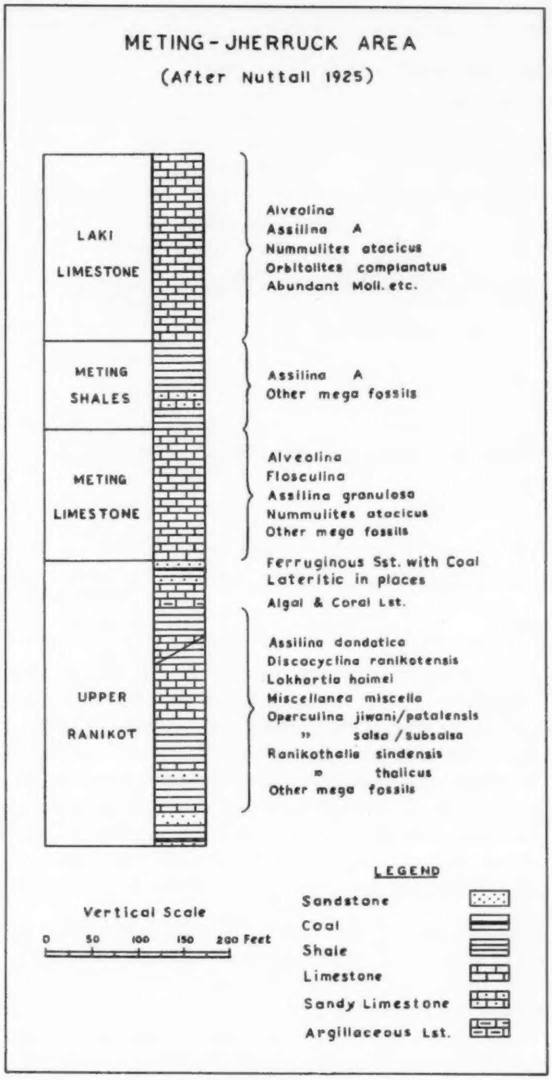
Stratigraphic divisions	*Lithology*	*Age*	
Lower Nari	Brown limestones, etc.		OLIGOCENE
Khirthar	Massive white limestone, with *Nummulites obtusus*, *N. laevigatus*, *Assilina spira*, etc. Thin-bedded shales, with limestones and sandstones Black limestone, with *Nummulites irregularis**, *N. laevigatus*, *Assilina exponens*, and its megalospheric form *A. mamillata*		MIDDLE EOCENE
	------------Unconformity------------		
Laki	Gypseous shales, sandstones, and occasional coal seams and limestones, with *Nummulites atacicus* and *Assilina granulosa*		LOWER EOCENE
	------------Unconformity------------		
Cardita beaumonti beds	Volcanic conglomerates and shales, with *Venericardia beaumonti*	Danian	Basal PALEOCENE
"Pab sandstone"	Massive coarse sandstones, sometimes with interbedded volcanic material	?Maestrichtian	UPPER CRETACEOUS
Upper Cretaceous shales *Hemipneustes* beds	Olive shales with numerous ammonites; volcanic material often associated Limestones and calcareous shales, with *Hemipneustes*	Maestrichtian	UPPER CRETACEOUS
Parh limestone	Flaggy porcellanic limestones and shales (Vredenburg's *Lituola* beds and the underlying Parh limestone are included here)	Cenomanian to Campanian	UPPER CRETACEOUS
Belemnite shales	Dark-coloured splintery shales, with abundant belemnites		LOWER CRETACEOUS
Jurassic limestones			

* *N. irregularis* has so far been found elsewhere only in the Laki.

farther east, in Sind. Not much is known about the higher rocks of the Eocene in this area; the Laki is either absent or is also represented by a deep-water argillaceous facies. The Khirthar, however, is represented, although often much disturbed, by detrital limestones containing abundant debris of typical Middle Eocene larger foraminifera.

Baluchistan (northern part)

In northern Baluchistan, although the Belemnite shale and Parh limestone group are present in much the same facies as in southern Baluchistan, the Maestrichtian and higher beds appear to have been formed as shelf deposits in shallow inner neritic environments, in some respects as in Sind. The



TEXT-FIGURE 5

TABLE 4

SUCCESSION IN DES VALLEY

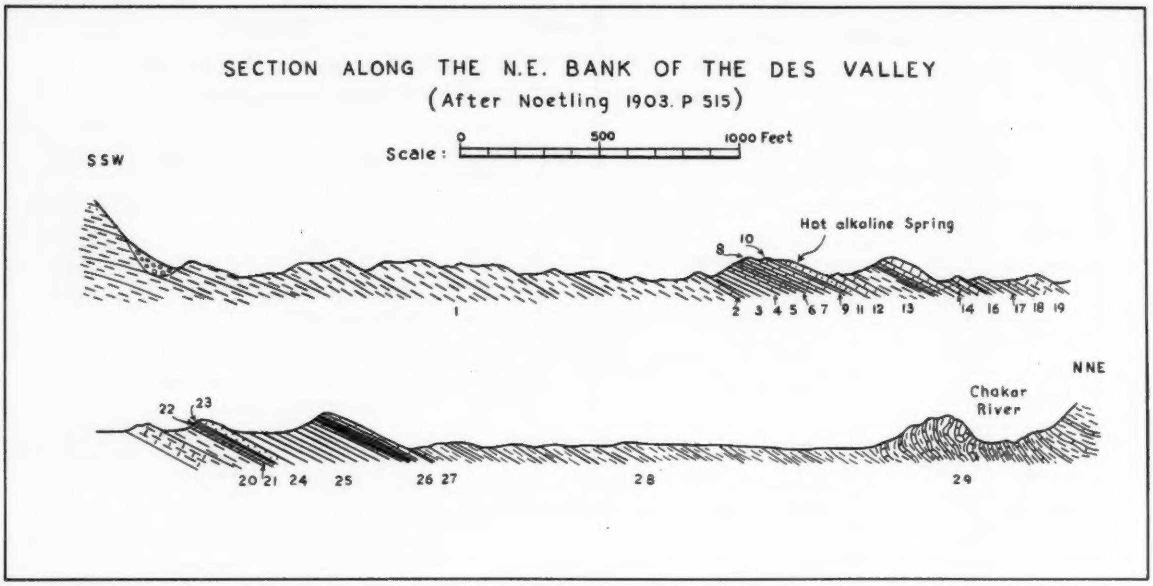
After Noetling (1903).

Zones and Thickness	*Lithology*	*Correlation*	*Age*
(27–29) 1550′	Olive-coloured soft clay and limestone, with *Assilina granulosa* in lower part	Ghazij shale	Laki (LOWER EOCENE)
(25–26) (?)100′	Dark blue shale, with limestone at the top	Dunghan limestone and Dunghan shale	Laki to Ranikot (LOWER EOCENE to PALEOCENE)
(19–24) 73′	Limestones, sandstones, and clays of various colours, brown and red predominant toward the top	*Cardita beaumonti* beds and *Hemipneustes* beds	Danian to Maestrichtian
(13–18) 90′	Dark blue nodular limestone, with clay partings and an unfossiliferous clay at the base	*Hemipneustes* beds	Maestrichtian
(2–12) 260′	Alternations of blue-grey limestones and clays		
(1) 1500′	Soft blue-grey unfossiliferous clay	Parh limestone and (?)Belemnite shales	Campanian (and possibly older)

records here are more complete, and some sections show perhaps the best Eocene sequence in the whole area. For much of the information in this area we are indebted to earlier pioneer workers such as Noetling, Vredenburg, and Nuttall, and, in more recent years, to the Burmah Oil Company's geologists, who carried out much detailed geological and palaeontological work in the area before the partition of the country in 1947. In the following account, free use has been made of information from all of these sources.

The area is vast, and a complete succession is difficult to find in any one locality. But an idea of the entire succession from the top of the Jurassic to the top of the Eocene can be obtained from an examination of the geology around Quetta, the Dunghan Range, the Mehrab Tangi, Bugti-Mari, and the Sulaiman Range.

The Des Valley area received early attention from Oldham and later from Noetling because of the oil possibilities in nearby Khattan. Noetling described a succession ranging from the Upper Cretaceous to the Lower Eocene. A similar succession is also observed in Khattan. Higher beds extending to the Khirthar are also present. The succession described by Noetling (1903), which is more or less representative of the area, is shown in Table 4 and text-figure 6.



TEXT-FIGURE 6

The argillaceous beds in this succession should yield abundant small foraminifera, which might provide better control, especially for Noetling's zones 1 and 19 to 26.

The Belemnite shale and Parh limestone outcropping in the neighbourhood of Quetta are thinner than the corresponding beds in Las Bela, and appear to be a condensed succession. This is remarkably well illustrated by the identical evolutionary sequence in the species of *Globotruncana*. This line starts with the single-keeled *Globotruncana appenninica* in the upper part of the Belemnite shale, and ends with *Globotruncana stuarti* in the highest levels of the Parh limestone. The fauna of the overlying *Hemipneustes* beds, which were locally included in the "Dunghan limestone" (Davies, 1940, pp. 199–200, 230), is identical with that of similar beds in the Lakhi Range in Sind, consisting of the typical Maestrichtian larger foraminifera *Omphalocyclus macropora*, *Orbitoides media*, and *Siderolites calcitrapoides*, and fragments of rudistids.

Oldham (1890, pp. 94–95), in describing the "Dunghan" group of the Marri Hills (Mazar Drik and Des Valley), included in this group some Cretaceous shales and limestones. Although Oldham correctly recognized the Cretaceous fossils associated with these shales and limestones, he mistook the *Orbitoides* for *Nummulites*, and thought that the "Dunghan" group represented a transition between the Cretaceous and the Eocene. La Touche (1893) also recorded a group of Cretaceous shales with *Orbitoides* (which he, too, mistook for small *Nummulites*) as part of the "Dunghan" group. In most of the other areas the "Dunghan limestone" is of basal Tertiary age (Pinfold, 1939), being either entirely of Laki age or of both Laki and Ranikot ages, as, for example, the Zinda Pir limestones and Zinda Pir shales (Eames, 1952*a*, p. 165), which are the local equivalents of the "Dunghan" group in Zinda Pir.

The succession above the Maestrichtian into the Paleocene is all limestone in a number of sections, but, even so, it is most interesting to note that between the beds with the typical Maestrichtian fauna listed above and those with typical Ranikot foraminifera a small thickness of limestone intervenes, which contains *Globigerina* and *Guembelina* in flood but lacks any trace of *Globorotalia* or *Globotruncana*.

In the Sulaiman Range, a fairly complete marine succession ranging from the Upper Cretaceous (Maestrichtian or Campanian) to the Upper Eocene is exposed along the Rakhi Nala and in Zinda Pir. A generalized succession of the Eocene rocks exposed on the eastern foothills of this range was given by Nuttall (1926*a*, p. 118), who, however, thought that the rocks did not represent the whole of the Eocene and considered the sequence as extending only to the lower part of the middle Khirthar. Based on the observations of the Burmah Oil Company's geologists, Eames (1952*a*, *b*) gave a detailed description of the Rakhi Nala section, from which it can be

TABLE 5

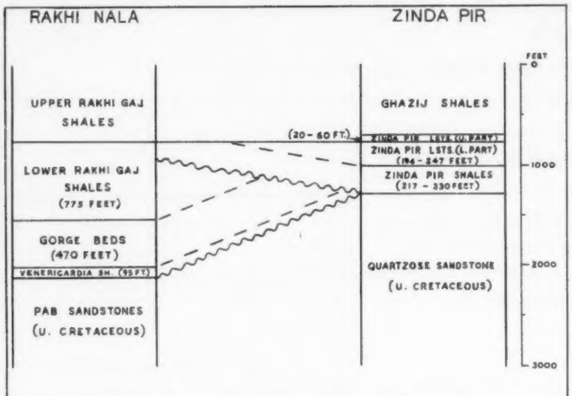
SUCCESSION IN SULAIMAN RANGE

Nuttall (1926, p. 118): *Generalized succession in Sulaiman Range*		Eames (1952, pp. 162–163): *Rakhi Nala section*		*Age*	
Lower part of middle Khirthar:		Upper Chocolate clays, including *Pellatispira* beds	1045′	Khirthar	UPPER EOCENE
Brown to blue shales	1200′				
Limestone	20–30′	White marl band	40′		MIDDLE EOCENE
Lower Khirthar:					
Blue-grey shales	900′	Lower Chocolate clays	930′		
Limestone	40′	Platy limestone	70′		
Massive gypsum	15′				
Blue-grey shales	400′	Shales with alabaster	750′	Laki	LOWER EOCENE
Massive limestone	1300′	Rubbly limestone	410′		
Laki series:					
Ghazij shales:		Green and nodular shales	850′		
Blue-grey shales	2000′	Upper Rakhigaj shales	1620′		
Dunghan limestone:					
Conglomeratic limestone	500′	Lower Rakhigaj shales	775′	Ranikot	PALEOCENE
Total	6385′	Gorge beds	470′		
		Venericardia shales	95′	Danian	
Not examined		"Pab sandstone"	1410′	?Maestrichtian	UPPER CRETACEOUS
		Orbitoides limestone and shale	640′	Maestrichtian to Campanian	
		Bedded clays	680′		
		Inoceramus clays	205′+		

seen that the succession exposed here extends well into the Upper Eocene. Table 5 gives a comparison of the stratigraphic succession given by Nuttall with that of the Rakhi Nala and Zinda Pir as given by Eames.

In the Rakhi Nala section, the lowest beds, the *Inoceramus* clays, contain *Bolivina incrassata* Reuss, *Globotruncana stuarti*, and *Globotruncana linneiana*, associated with *Inoceramus* and ammonites. This and the next succeeding beds probably correspond to the uppermost levels of the Parh limestone as developed in eastern and southern Baluchistan. The *Orbitoides* limestone and shales contain the same typical Maestrichtian assemblage of larger foraminifera so characteristic of this horizon (*Hemipneustes* beds) in Sind. The small foraminifera are not characteristic, but since collections were not made from the argillaceous bands, this observation may need further modification.

The overlying sandstone group has, as in Sind, been called the "Pab sandstone." As was pointed out earlier, in the type area this group lies wholly within or at the base of the Maestrichtian. As in Sind, no foraminifera were found at any level in this arenaceous group. The overlying *Venericardia* shales contain neither *Globorotalia* nor *Globotruncana*. The first appearance of *Globigerina pseudobulloides* and *Globigerina triloculinoides* is again found here, suggesting a Danian age for these beds (compare the *Cardita beaumonti* beds of Sind). The Gorge beds,



Correlation of the lower parts of the Rakhi Nala and Zinda Pir Eocene (After Eames 1952)

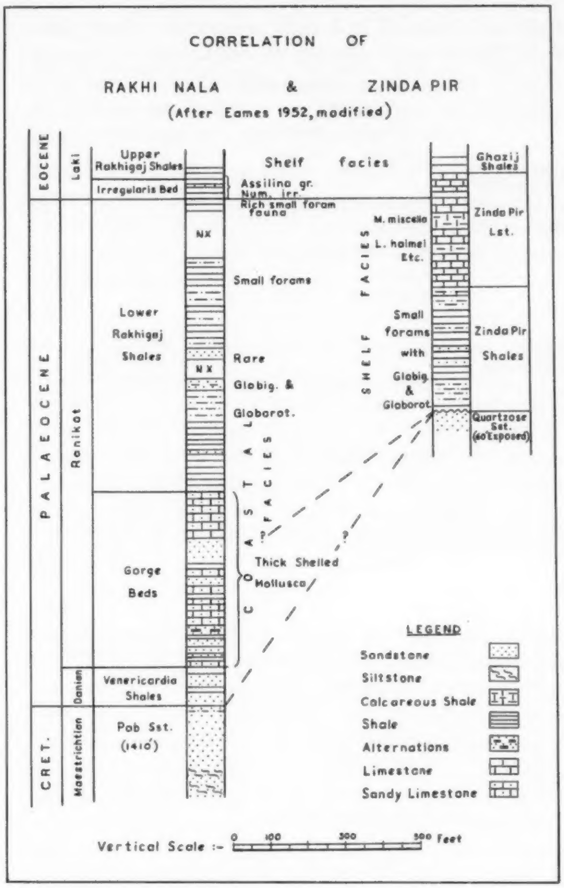
TEXT-FIGURE 7

with their shell beds, must have been deposited in a littoral environment, and must represent a minor regression that continued into the basal part of the lower Rakhigaj shales; they consist mainly of sandy strata with few or no foraminifera (they are virtually unfossiliferous). Higher beds in the lower Rakhigaj shales represent an open-sea deposit, and mark the beginning of another transgression. The foraminifera here consist of abundant pelagic forms, such as *Globigerina* and the first *Globorotalia*. Other genera and species present in the assemblage here are: *Anomalina* cf. *acuta* (Plummer), *Bolivina*, *Cassidulina*, *Cibicides alleni* (Plummer), *Frondicularia* aff. *midwayensis* Cushman, *Gaudryina carinata* Franke, *Globorotalia* cf. *velascoensis*, *Guembelina globulosa* (Ehrenberg), *Gyroidina girardana* (Reuss), *Lenticulina*, *Marssonella*, *Palmula reticulata* (Reuss), *Textularia*, and *Vaginulina*. This fauna is of Paleocene aspect, and probably represents Ranikot age.

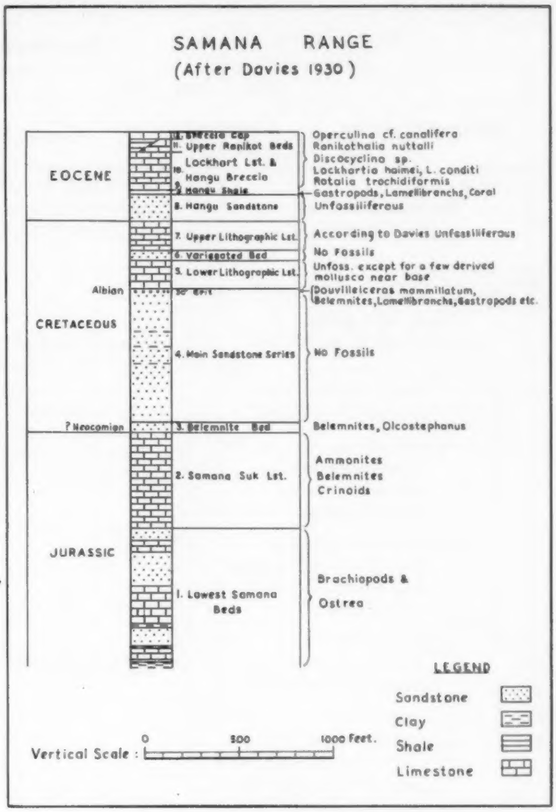
There is a small gap in the succession between the limit of the fauna listed above and the *Irregularis* bed. The *Irregularis* bed contains the first Laki larger foraminifera (*Nummulites irregularis* Deshayes, *Nummulites atacicus*, *Assilina granulosa*, and others) in the section, but the associated small foraminifera are present also in the shales immediately above and below. These beds may be taken as representing the basal Laki. Because of lack of evidence in the interval between the strata containing the Ranikot fauna and the above-mentioned basal Laki beds, it is difficult to place the Laki/Ranikot boundary accurately in this section. In Zinda Pir, the corresponding succession consists of foraminiferal detrital limestones and shales with typical Ranikot (Paleocene) foraminifera, followed by the basal Laki *Irregularis* bed and a thick group of shales which is the equivalent of the Ghazij shales elsewhere. The upper Rakhigaj shales of the Rakhi Nala, and the Ghazij shales of Zinda Pir contain an identical foraminiferal fauna. The Eocene succession from here upward in the two areas is identical.

The correlation of the lower beds of the Rakhi Nala and Zinda Pir, as shown by Eames (1952*b*, p. 186), does not seem to take into consideration changes in lithology and depositional environments (text-fig. 7). The Gorge beds are typical shell beds formed on the beach under strong wave action. The thick-shelled mollusks and the extremely hard sandy limestone beds both testify to this. The overlying strata forming the basal part of the lower Rakhigaj shales seem to suggest a continuation of the same shallow-water environment, but with more sand and silt. The Zinda Pir limestones, on the other hand, are typical shallow-water shelf deposits made up of detrital material derived mostly from foraminiferal debris. They can be regarded as a biostrome deposited in an "off-reef" environment. On the basis of these considerations, a new correlation is submitted here as a more reasonable alternative (see text-fig. 8).

It is interesting to follow the evolution of the assilines and nummulites through the Laki. There are only two important species of *Assilina* present: In the lower part typical *Assilina granulosa* is found in association with *Nummulites irregularis*; this assiline is soon replaced by the extremely variable *Assilina* sp. *A*, which recalls, to some extent, the ornamentation of the well known Khirthar form *Assilina papillata*. Toward the higher reaches of the Laki, this form is gradually replaced by a more robust and heavily ornamented variety. The nummulites also show progressive variation. The lowest levels of the Laki are dominated by *Nummulites irregularis* and *Nummulites atacicus*, both rather large forms. They are soon replaced by two small, variable forms; one is *Nummulites pinfoldi* Davies, and the other appears to be a new form, which is very granular on the surface to start with and gradually becomes less so during its progress in time until, in the higher levels of the Laki, it often bears only a single granule in the polar region. The test also tends to become more lenticular. *Nummulites pinfoldi* too is highly variable; in the lower part of the Laki, it has as many as five or six small pillars in the polar region, which, in the higher beds of the Laki, gradually merge to form a single large polar pustule, often with the central depression so characteristic of the typical *Nummulites pinfoldi* from the Kohat shales of Kohat. Smaller foraminifera probably show similar evolutionary changes, but they have not yet been studied.



TEXT-FIGURE 8



TEXT-FIGURE 9

The Khirthar, in contrast with its development in Sind and southern Baluchistan, is developed predominantly as an argillaceous sequence with thin limestone or marly bands interspersed. The common foraminiferal genus here is *Discocyclina*. The fauna consists of *Nummulites pengaronensis* Verbeek, *Nummulites beaumonti* d'Archiac and Haime, *Assilina exponens* (Sowerby), *Assilina cancellata* Nuttall, *Assilina papillata*, *Discocyclina dispansa*, *Discocyclina sowerbyi*, *Discocyclina undulata* Nuttall, and *Discocyclina omphala* (Fritsch) var., some of which are well known Middle Eocene forms. *Nummulites pengaronensis* comes in a little later in the succession and persists to the very top of the Eocene. In the higher levels of the upper Chocolate clays, *Assilina* is absent; *Pellatispira* takes the place of *Assilina*, and the nummulites have developed a new race, the reticulate group. The upper Chocolate clays contain a large number of small foraminifera and Ostracoda. Much of this fauna has yet to be examined in detail. Some of the important species occurring in this fauna are: *Angulogerina* cf. *vicksburgensis* Cushman, *Cibicides cooperensis* Cushman, *Guembelina venezuelana* Nuttall, and *Hantkenina alabamensis* Cushman.

Samana Range

The eastern portion of the Samana Range was examined by Griesbach soon after its military occupation in 1891 (Griesbach, 1893). Details of the complete succession ranging from the Jurassic to the Paleocene are to be found in Davies's account of this area (Davies, 1930*b*, pp. 1–15). Except for the Paleocene Ranikot beds, there is no record of foraminifera from the other members of the succession. For the lower lithographic limestone (Davies's Bed 5; see text-fig. 9), Davies has suggested a correlation with the Chikkim series of the Spiti Valley (see below); its lithologic character, which is comparable with that of the Parh limestone, also supports this view. If so, the limestone should yield *Globotruncana*, and it is essential to make a careful examination of this limestone to see whether or not the suggested correlation can be confirmed. Similarly, the upper

TABLE 6
SUCCESSION NEAR KOHAT

	After Eames (1952)			After Wadia and Davies (1929)		
	Stratigraphic division	*Maximum thickness*	*Foraminifera*	*Stratigraphic division*	*Maximum thickness*	*Age and correlation*
	Sirki shales Brown shale with impure limestone	15′	*Assilina rota*, *Alveolina*, *Nummulites pengaronensis*, *N. perforatus*, *N. atacicus*, *Orbitolites complanatus*	Yellow nodular limestone and grey flaggy or massive limestone	120′	
	Kohat limestone Hard, light grey foraminiferal limestone	250′				Mainly MIDDLE EOCENE (Khirthar)
Upper Chharat	Nummulite shales Highly calcareous foraminiferal shales	140′	*Alveolina*, *Lockhartia*, *Lituonella*, *Coskinolina*, *Dictyoconus*, *Orbitolites complanatus*, *Assilina papillata*, *Dictyoconoides cooki*, *Linderina*, *Nummulites perforatus*, *N. obtusus*, *N. atacicus*, *N. pinfoldi*, *Cibicides*, *Cyclammina*, etc.	Nummulite shale	130′	
Upper Chharat	Kohat shales Olive-green shales with thin foraminiferal bands	110′		Kohat shale	100′	
Lower Chharat	*Ostrea* alternations Blue-green shales with thin bands of limestone with *Ostrea*	30′		Lower Chharat	575′	
Lower Chharat	*Planorbis* bed Hard grey limestone, lower part dolomitic	7′	Rare small foraminifera	Light grey limestone		(?)MIDDLE EOCENE (?Khirthar)
Lower Chharat	Crimson clays Ferruginous sandy clays, clayey shales with some impure gypsum	258′		Blue shales Red clays		
	Shekhan limestone Hard grey to brown limestone; gypsiferous beds near top Nodular limestones alternating with green shales	325′	*Alveolina*, *Assilina daviesi*, *A. laminosa*, *Discocyclina*, *Nummulites atacicus*, *N.* cf. *pinfoldi*, *Orbitolites complanatus*, *Operculina*, *Asterigerina*, *Cibicides*, *Discorbis*, miliolids, etc.	Laki limestone	200′	
	Panoba shales Olive-green splintery shales, with a bed crowded with small assilines near top	315′	*Assilina daviesi*, *Nummulites* cf. *pinfoldi* near top; mostly poorly fossiliferous	Meting shale	320′	LOWER EOCENE (Laki)
	Tarkhobi shales Black calcareous shales and thin limestone bands, with foraminifera	400′+		- - - - - - - - - - -		
	A thick band of grey hard foraminiferal limestone (up to 50′)		*Alveolina*, *Orbitolites complanatus*, *Assilina granulosa*, *A. daviesi*, *Nummulites irregularis*, *N. kelatensis*, *N. atacicus*, *Discocyclina ranikotensis*; rich in small foraminifera	Apparently not recorded; shown as unconformity		
	Dark green to black carbonaceous shales					
	Brecciated limestones and shales	130′	*Miscellanea miscella*, *M. meandrina*, *Lockhartia haimei*, *L. conditi*, *Operculina patalensis*, *Orbitosiphon tibetica*, *Discocyclina*; small foraminifera fairly common	- - - - - - - - - - -		PALEOCENE (Ranikot)
	Hard "brecciated" limestones					
	Tarkhobi limestone Hard, massive foraminiferal and algal limestones	360′+		Ranikot limestone		

lithographic limestone (Bed 7 of Davies) also needs a careful examination for smaller foraminifera, since it is clear from the observations of Davies (1930*b*, p. 8) that this bed has no fossils that can be easily detected with the unaided eye.

In the rest of the succession, Beds 10 to 12 are important and have yielded typical Ranikot larger foraminifera. Virtually no information is on record concerning any small foraminifera that may be present in these beds.

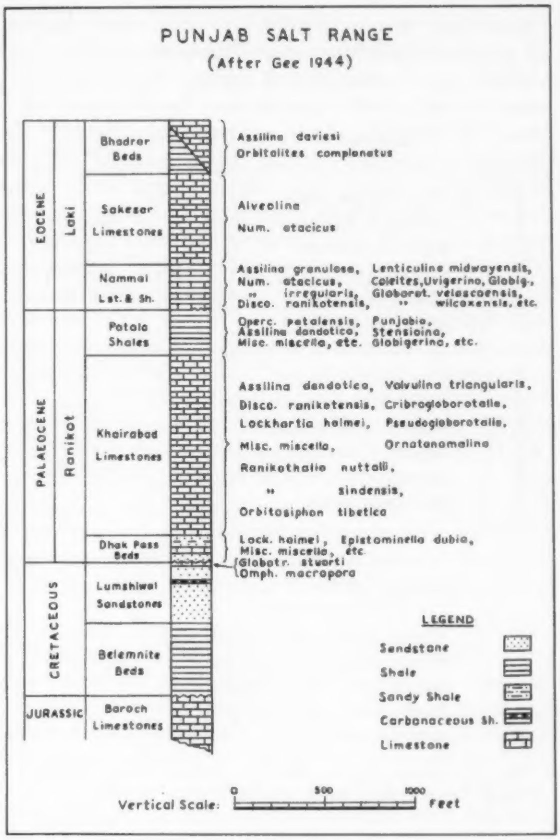
Kohat

The most recent literature on the succession in the neighbourhood of Kohat is that of Eames (1952*a*, *b*). Rocks older than the Ranikot are not exposed in this area. The best exposures are found in the Tarkhobi-Panoba and Shekhan Nala sections. Earlier, Davies had done considerable work in this area (see Davies, 1925, 1926, 1927, and Wadia and Davies, 1929). Table 6 gives the stratigraphy and associated foraminiferal fauna.

Punjab

In the Punjab, there is a good development of the Cretaceous–Eocene sequence in the hills bordering the Potwar. On the south, in the Salt Range, the Cretaceous is represented by the Belemnite beds and the Lumshiwal sandstone (Gee, 1944). Foraminifera have not been studied from this group. In the Nammal Gorge, it has been reported that the 18-foot "Baroch limestone," occurring just below the Dhak Pass beds, contains *Globotruncana* and *Omphalocyclus* and should therefore be of Maestrichtian age (Rao and Tripathi, 1950). This raises the question of whether or not the Baroch limestone farther west, which occurs *below* the Belemnite beds, is also of Maestrichtian age. This seems impossible, since the Belemnite beds contain a megafauna of Neocomian age. It is more likely that in the Nammal Gorge, the thin limestone of Maestrichtian age recorded by Rao and Tripathi has been erroneously referred to the Baroch limestone, which elsewhere is of Jurassic age.

There is an unconformity at the base of the Tertiary in the Salt Range (text-fig. 10), which cuts out progressively more of the Mesozoic and older beds eastward (Gee, 1944, p. 274). In the Eocene, only the Ranikot and the Laki are developed here, but to the north, in the Kala Chitta range, the Khirthar also is found. The succession in the Kala Chitta is, however, complicated by intense faulting and folding, with the result that a full sequence is nowhere to be seen; even the section near Chharat, which is more complete than the others, is much faulted (Pinfold, 1918, pl. 4). Beds older than the Eocene



TEXT-FIGURE 10

are not exposed in the locality, and from Pinfold's writing (op.cit., pp. 143–145, 151, 159) it is clear that the lowest beds near Chharat are of Laki age. The succession is shown in Table 7. From the description of the beds and their fauna as given by Pinfold, the following correlation with the Kohat succession can be suggested:

Chharat		Kohat
4) Nummulite shale	Upper Chharat	Nummulite shale
3) Limestones and shales		Kohat shales
2) Variegated shales	Lower Chharat	Lower Chharat
1) Massive limestone and passage beds		Shekhan limestone

The fauna of the Salt Range Eocene has been described by Davies (Davies and Pinfold, 1937). As in Sind and Baluchistan, the Ranikot is characterized by *Miscellanea*, *Ranikothalia*, simple forms of *Discocyclina*, small assilines and alveolines. True nummulites are small when present, but the genus *Ranikothalia* is represented by its genotype, *Ranikothalia nuttalli*

Table 7
Succession near Chharat
After Pinfold (1918).

<table>
<tr><th></th><th>Sequence</th><th>Thickness</th><th>Age and correlation</th></tr>
<tr><td rowspan="2">Upper Chharat</td><td>4) Nummulite shale
Greenish shales crowded with *Nummulites*</td><td>200′</td><td rowspan="2">Mainly MIDDLE EOCENE (Khirthar)</td></tr>
<tr><td>3) Limestones and shales
Green shales with white limestone bands</td><td>200′</td></tr>
<tr><td>Lower Chharat</td><td>2) Variegated shales
Bright-coloured shales with thin limestone bands. Fibrous gypsum occurs, especially in the lower beds</td><td>300–500′</td><td>(?)MIDDLE EOCENE (?Khirthar)</td></tr>
<tr><td></td><td>1) Massive limestone and passage beds (= Hill limestone)*
Massive limestones with small Nummulites in upper part, overlain by white chalky limestones with fibrous gypsum and calcite</td><td>?</td><td>LOWER EOCENE (Laki)</td></tr>
</table>

* The Hill limestone is believed to extend into the Ranikot, but its foraminiferal fauna is insufficiently known.

(Davies), and also by *Ranikothalia sindensis* (Davies). In the basal Laki, as in Baluchistan, the characteristic forms are *Nummulites irregularis* and *Nummulites atacicus*, together with other simple species of *Nummulites*. Alveolines and assilines, as well as *Lockhartia*, are abundant in the Ranikot and Laki. The dominant species of *Assilina* in the highest Eocene here, the Bhadrar beds, is *Assilina daviesi* de Cizancourt (Gill, 1953).

Abundant small foraminifera occur in these beds, and some of the more argillaceous layers have yielded excellent free specimens. The small foraminifera of the Nammal Gorge section have been studied by Haque (1956). Some of the important forms characteristic of the Ranikot and the Laki taken from the rich assemblage described by Haque are listed below:

Ranikot: *Anomalina bandyi* Haque
Cibicides lobatulus (Walker and Jacob)
Planorbulinella
Pseudogloborotalia
Punjabia
Valvulina triangularis (d'Orbigny)

Laki: *Alabamina wilcoxensis* Toulmin
Anomalina acuta Plummer
Astacolus mexicanus (Cushman)
Bulimina pupoides d'Orbigny
Bulimina reussi Morrow
Dorothia bulleta (Carsey)
Eponides lotus (Schwager)
Gaudryina laevigata Franke
Gaudryina tazaensis Carbonnier
Globanomalina ovalis Haque
Globanomalina simplex Haque
Globorotalia velascoensis (Cushman)
Loxostomum applinae (Plummer)
Nodosaria nammalensis Haque
Nodosaria radicula (Linné)
Pseudoclavulina pseudohumilis Haque
Quinqueloculina gapperi Haque
Robulus midwayensis (Plummer)
Textularia mississippiensis Cushman
Textularia plummerae Lalicker

Kashmir

Cretaceous outcrops are known at Burzil in northwestern Kashmir (Wadia, 1934, 1935), where *Orbitolina*-bearing limestones occur in association with intrusive granites and volcanics (ash beds, tuffs, agglomerates, and bedded lava flows). The marine sedimentaries occur as lenticular layers interspersed within the much folded volcanics. According to Douvillé, the *Orbitolina* indicates a Lower Cretaceous (Barremian) age. Hippuritic limestones of Cretaceous age are also known from Ladakh, and here too, associated with volcanic rocks, *Orbitolina*-bearing limestones occur. Some of these are believed to be of Middle and Upper Cretaceous age. The foraminiferal fauna of these remote and relatively inaccessible areas is practically unknown, except for the above-mentioned *Orbitolina*.

In the Pir Panjal and the syntaxial region, a narrow band of Eocene rocks is exposed. These rocks are represented mainly by fossiliferous limestones and shales with some coal near the base. They appear to be a continuation of the Shekhan limestone and the other members of the Lower Eocene of the Kohat area. A more critical study of the foraminifera is needed in order to understand the full faunal sequence present in these rocks. The few foraminifera identified (*Nummulites atacicus* and *Assilina granulosa*) indicate a Laki age. Only a systematic study can reveal whether these foraminifera occur throughout the Eocene of this area or are confined to a particular horizon.

Spiti Valley

In the Spiti Valley, approximately north-northeast of Simla, Stoliczka (1865) and Spitz (1914) reported the occurrence of small foraminifera in the Chikkim limestone. The genera recorded by them are *Cristellaria*, "*Haplophragmium*," *Nodosaria*, *Rotalia* and *Textularia*. More recently, *Globotruncana* has been reported from near Chikkim and Koigar (Kohli and Sastri, 1956). The succession examined by them includes:

Chikkim shales:	Grey-green calcareous sandy shales . . . over 150′
Chikkim limestone:	Massive grey fine-grained limestone with abundant foraminifera, overlain by a small thickness of shaly beds . . . about 100′
Giumal sandstone	

Globotruncana stuarti has been found in the higher beds of the Chikkim limestone, and the associated fauna suggests a Maestrichtian age for this horizon. This is in conformity with the earlier age assignment of these beds. Immediately underlying the Chikkim limestone is a thin bed of calcareous quartzite which contains *Belemnites*. *Belemnites* is also common in certain places at the base of the Chikkim limestone. Until the foraminiferal fauna of the entire sequence is known, it will not be possible to determine the full interval represented by the Cretaceous rocks in this area.

Wadia (1953, p. 270) reports that the Chikkim series is widely distributed, like the Spiti shales (Upper Jurassic to lowermost Cretaceous), outcrops being known from Kashmir, Hazara, Kumaon, Tibet, Afghanistan, and Persia. Our present knowledge of the foraminifera of this extensive series is limited to a very small part of the succession in one area, and it becomes apparent that, in order to establish a reliable correlation of the rocks of this series, a considerable amount of information remains to be gathered. Higher beds are known from the Simla area, where the Subathu series includes Laki and probably other Eocene beds.

Tibet

Much of our present knowledge of the sedimentary rocks of southern and central Tibet is based on Hayden's reconnaissance of 1903–04, when he accompanied the British Mission to Lhasa. Some geological observations in the region west and northwest of Shigatse, gathered during his explorations in 1901 and 1906–08, are recorded in Sven Hedin's "Southern Tibet" (see Hennig, 1916). On the basis of an examination of the fossils collected by Sven Hedin, Hennig (1916, pl. B) compiled a geologic map of the area; but this map, though providing a general picture of the geology of the area, cannot be considered accurate. Geologic data recorded during the several Everest expeditions were confined mostly to rocks older than the Cretaceous. During his second visit to Tibet, in 1922, Hayden made geologic observations over a large area to the north, west and southeast of Lhasa. The available information (Coulson, 1933) is insufficient to establish the geologic succession, but it is clear from Cotter (1929) that Cretaceous rocks are definitely present. Much of the discussion that follows is confined to the Kampa Dzong region, where it was possible for Hayden, during his earlier reconnaissance, to make a more detailed examination of the succession, which is shown in Table 8 (after Hayden, 1905 and 1907).

The oldest Cretaceous rocks are probably the uppermost beds of the Spiti shales. The overlying Giri limestone is regarded as Lower Cretaceous from its stratigraphic position, but no fossils have been recorded from this limestone. From the observations of Sven Hedin (1916, and in Wadia, 1953, p. 271) and of Hayden (Coulson, 1933), it is apparent that the Cretaceous rocks cover a large area beyond Lhasa to the north and northwest. Some of these rocks contain *Orbitolina tibetica* Cotter and *Choffatella*, and have been regarded by Douvillé (1916*b*, in Sven Hedin) and by Cotter (1929) as of Barremian to Hauterivian age.

There is no record of foraminifera from the Kampa Ammonite shales and the overlying *Hemiaster* shales, but they seem to suggest correlation with the Belemnite shales of Baluchistan; both Hayden and Vredenburg have placed these two groups in the Cenomanian. Most of the higher rocks contain foraminifera of Tethyan facies which compare well with those of Sind and Baluchistan. Vredenburg (1908) records *Orbitoides media* and *Omphalocyclus macropora* from the major part of the succession above the *Hemiaster* shales to near the top of the Tuna limestone, suggesting a Maestrichtian age. The topmost beds of the Tuna limestone are considered by Vredenburg to be equivalent to the *Cardita beaumonti* beds (Danian) of Sind and Baluchistan. The foraminiferal fauna of the higher beds (Davies and Pinfold, 1937) consists of typical Ranikot and Laki assemblages. A systematic study of the foraminiferal faunas of the complete sequence

TABLE 8
SUCCESSION IN CENTRAL TIBET
After Hayden.

Lithologic division	*Lithology*	*Thickness*	*Age*	
Dzongbuk shales	Dark-coloured shales	?	Laki	LOWER EOCENE
Alveoline limestone	Hard limestone with abundant *Alveolina*	100′		
Shales and limestones	Unfossiliferous group of shales and some limestones	400′		
Sandy shale	Sandy micaceous shale with thin sandstone flags	150′		
Orbitolites limestone	Limestone with abundant *Orbitolites, Alveolina,* and miliolids	50′		
Spondylus shales	Fine-grained greenish grey to black needle shales	150′	Ranikot	PALEOCENE
Operculina limestone	Soft shaly and nodular foraminiferal limestone with *Operculina*, etc.	150′		
Gastropod limestone	Hard, dark, massive limestone, thin-bedded at base	300′		
Ferruginous sandstone	Ferruginous sandstone (Typical Ranikot foraminifera, including *Miscellanea, Ranikothalia, Orbitosiphon tibetica, Lockhartia*, etc.)	200′		
Tuna limestones	Grey limestone with echinoids and brachiopods	50′	Danian	
	Sandstone (unfossiliferous)	30′		
	Lithothamnion limestone with *Omphalocyclus macropora, Orbitoides,* and *Cyclolites*; Red arenaceous limestone with *Hemiaster, Plicatula* and *Neithea quadricostata*; Grey limestone	20′	Maestrichtian	UPPER CRETACEOUS
	Brown limestone with *Omphalocyclus* and *Neithea quadricostata*; Thin-bedded limestone with *Orbitoides media*	40′		
Third Scarp limestone	Massive limestone (*Radiolites, Orbitoides media*)	105′		
	Calcareous shale, thin flaggy and shaly limestone (*Radiolites, Orbitoides media*)	115′		
Second Scarp limestone	Massive limestone (*Orbitoides media, rudistids*)	135′		
	Calcareous shale (*Gryphaea*)	150′		
First Scarp limestone	Massive hard and splintery limestone (No determinable fossils)	155′		
Hemiaster shales	Pale grey shale with *Hemiaster*	250–300′	Campanian to Cenomanian	
Kampa ammonite shales	Brown shaly limestones with brown and black needle shales containing ammonites	350′		
Giri limestone	Hard thin-bedded limestone, apparently unfossiliferous	400′	LOWER CRETACEOUS	
Spiti shales			JURASSIC, possibly extending into LOWER CRETACEOUS	

exposed in the Tibetan area would serve as a very important link between the faunal sequences of the western (Sind-Baluchistan) Tethyan province and the eastern provinces of Assam and Burma.

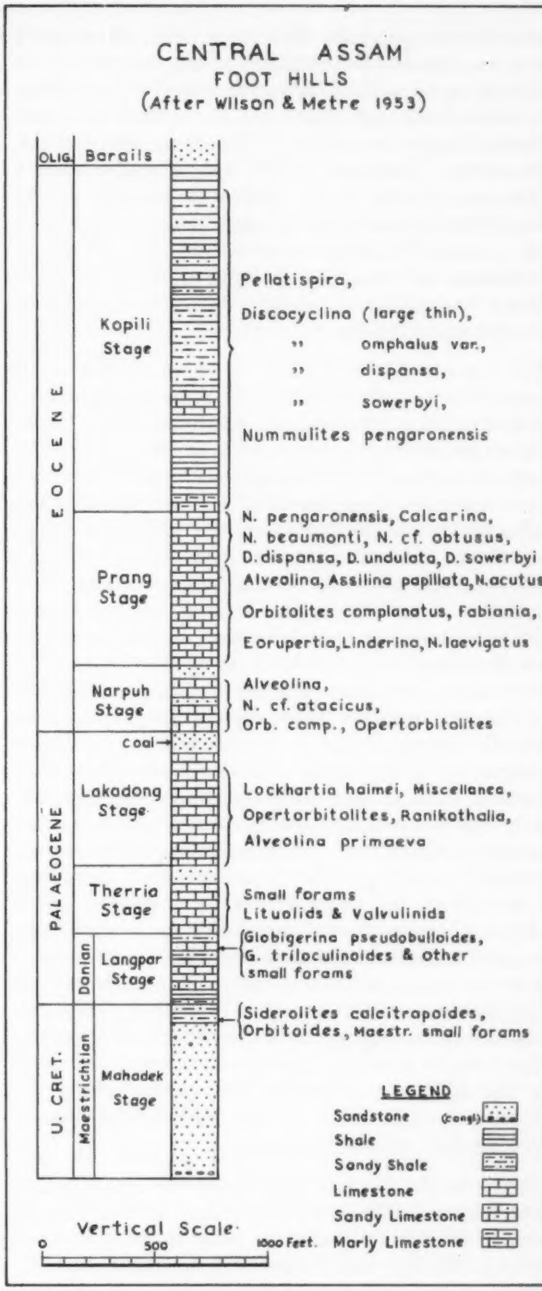
Central Assam

Nearly 300 miles southeast of the Tibetan area just discussed is central Assam, where a good development of Cretaceous and Eocene rocks is found in a narrow strip fringing the Shillong Plateau on the south (Evans, 1932). The Eocene outcrops extend westward into the Garo Hills, and on the east as far as the Mikir Hills. Text-figure 11, which gives a generalized idea of the Cretaceous–Eocene sequence in this area, is based on Wilson and Metre's account (1953). More recently, Eocene rocks have also been encountered in two deep test wells in the Nahorkatiya area and in the first test well in Moran.

Cretaceous rocks are confined to the Khasi and Jaintia Hills, where they consist of a basal conglomerate bed followed by coarse, massive ferruginous and glauconitic sandstones, which form theMahadek stage. At the top of this stage there are a few thin calcareous bands and some argillaceous beds, which have yielded Maestrichtian foraminifera including *Globotruncana stuarti*, *Guembelina plummerae*, *Orbitoides*, *Pseudotextularia*, and *Siderolites calcitrapoides*. Overlying the Mahadek stage is a group known as the Langpar stage, with calcareous shales and impure limestones containing the foraminifera *Globigerina pseudobulloides* and *Globigerina triloculinoides*, which, together with others, indicate a Danian age. Apparently, Cretaceous beds much older than the Maestrichtian are not exposed, at least in this part of Assam. Elsewhere, for example in the virtually unknown interior parts of the Naga Hills, Cretaceous rocks older than the Maestrichtian may be present.

There seems to be a gradual passage from the Langpar through the Therria stage into the Sylhet limestone. The Sylhet limestone consists of highly foraminiferal detrital limestones with abundant foraminifera and algae. The lithology of this and the overlying Kopili stage, which represent the highest Eocene beds in the area, varies considerably, becoming progressively arenaceous to the west and, to a lesser extent, also to the northeast. In the central part of the foothills (Khasi and Jaintia Hills), the rocks are more calcareous.

The Therria stage also contains foraminifera, but since most of the rock is hard limestone or sandy limestone, the foraminiferal fauna can be recognized only in thin sections. Much of this fauna therefore cannot be easily identified. There seem to be a large number of porcellanous and arenaceous forms,



TEXT-FIGURE 11

calcareous perforate forms being subordinate. These rocks are dolomitic in places, and then, of course, the fossils are obliterated, often beyond recognition.

The Sylhet limestone is now known to contain equivalents of the Ranikot, Laki and Khirthar. The

limestone is generally very hard, and, although it contains abundant foraminifera, the only means of identifying these fossils is by examining thin sections. In the lowest part there are the typical Tethyan Ranikot larger foraminifera *Miscellanea*, *Ranikothalia*, *Discocyclina*, *Lockhartia haimei*, etc., together with a species of *Gypsina* that seems to be peculiar to this area. This *Gypsina* does not appear to be present in the purely Tethyan area of western Pakistan. Miliolids, alveolines, and algae abound in these rocks, indicating a warm, clear, shallow-water marine environment.

The Laki, unlike the Laki of western Pakistan, is very thin (less than 200 feet, compared with 2000 feet or more), and contains a few nummulites (*Nummulites atacicus* being common), abundant small and large alveolines, and *Orbitolites complanatus*. Assilines have not so far been found. The development in the Khirthar, which includes both the Middle and Upper Eocene, is also different from that of western Pakistan; in Assam there seems to be a smaller total thickness of the Middle Eocene, although the Upper Eocene is much better developed, being intermediate between that of Burma (Indo-Pacific), on the one hand, and that of western Pakistan and the Himalayan region (Tethyan) on the other. The Middle Eocene fauna is much the same, with less variety of nummulites. The Tethyan *Nummulites acutus* occurring here seems to show some relationship with *Nummulites yawensis* Cotter, which is common in the Yaw shales of Burma; *Nummulites obtusus*, which in western Pakistan shows numerous pillars, is devoid of any trace of pillars in Assam, but is identical with typical *Nummulites obtusus* in all other respects. *Assilina papillata* is also found, but is more delicately ornamented. *Eorupertia* is common, and *Fabiania* occurs occasionally (Nagappa, 1956). Alveolines do not appear to show any differences from the group of *Alveolina elliptica*, which is very common in the Khirthar of western Pakistan. Among the discocyclines, a variety of the Indo-Pacific *Discocyclina omphala* occurs commonly.

Higher in the Eocene sequence is the Kopili stage, which overlies the Sylhet limestone. Even below the top of the Sylhet limestone, most of the alveolines seem to die out, and the assilines become extinct. In the Kopili stage, these forms are replaced by *Pellatispira*, which shows a fair amount of variety, again being intermediate between the Tethyan facies of western Pakistan, where only one species is known over a short range near the top of the Eocene development, and the typically Indo-Pacific facies of Burma (comparing favourably with what is known of this genus in Indonesia), where this genus is well represented by several species occurring in the upper part of the Pondaung stage and throughout the Yaw stage. In Broach and Rajpipla, a small thickness of Upper Eocene beds contains some of the common species of *Pellatispira* occurring in Assam and Burma. Reticulate Nummulites and certain types of *Operculina* are also found in the uppermost part of the Eocene in central Assam. The small foraminifera have not been fully examined, but the characteristic Upper Eocene pelagic form *Hantkenina alabamensis* is found in the Kopili stage (Biswas, 1954). Other common small foraminifera are *Angulogerina* cf. *vicksburgensis*, *Guembelina venezuelana*, *Halkyardia minima* (Liebus), *Robulus welchi* Church, and *Vaginulinopsis saundersi* Hanna and Hanna.

In the Naga Hills there is a monotonous development of mainly argillaceous beds known as the Disangs. Much of this part of the country is either unexplored or has received only a cursory examination. Where they have been examined, the rocks are much disturbed by thrusting and folding, and often show irregular dips. In two localities (Chantongia and near Harangajao), Upper Eocene larger foraminifera, including reticulate nummulites, have been found in the upper part. Some arenaceous small foraminifera, such as *Ammobaculites*, *Ammodiscus*, *Bathysiphon*, *Cyclammina*, *Gaudryina*, and *Haplophragmoides*, have been found in the Disangs underlying the Barails near Damchara. Some of these fossils also occur in Chantongia. Except for this scanty information, which suggests that the top of the Disangs is probably not younger than the Upper Eocene, there is no other fossil evidence available. It is, however, believed that the lower limit of the group may extend into the Cretaceous.

Burma

Our knowledge of the Cretaceous rocks of Burma is very meagre, being confined to a few localities in the Hukawng Valley and the Irrawaddy defile in Upper Burma and in the Arakan Yomas. The Eocene, however, is fairly well known and extends all along the foothills of the Arakan Yoma on the western margin of the Irrawaddy basin in central Burma. Some Cretaceous and Eocene rocks are also known from the Arakan, especially in the islands of Ramree and Cheduba. Detailed geologic work carried out by the geologists of the Burmah Oil Company has shown that the Tertiary rocks of the Burmese Gulf show a gradual transition from a marine facies to a fluviatile facies in a northerly direction, with interdigitation of marine and non-marine sediments. Stamp (in Chibber, 1934, pp. 212–214) attributes these changes to a series of oscillations of the sea-level (transgressions and regressions).

In the Hukawng Valley, isolated outcrops of *Orbitolina*-bearing Cretaceous limestone have been reported by Clegg and Day (Krishnan, 1953, pp. 302–303). Derived fragments of this limestone were also found at one locality in a limestone conglomerate of Eocene age containing *Nummulites obtusus*, *Discocyclina dispansa*, etc. The *Orbitolina* appears to be identical with *Orbitolina birmanica* Sahni, which is common in a limestone exposed along the second defile of the Irrawaddy (Sahni, 1937). No other foraminifera have been identified from these limestones, and the age determination has had to be based on the indirect evidence of *Orbitolina*.

Discussing the age of the *Orbitolina*-bearing beds in the second defile of the Irrawaddy, Sahni states: "Comparison of *Orbitolina birmanica* with orbitolines from the Tibetan region appears to indicate that a Lower Cretaceous (probably uppermost Barremian) age may be assigned to at least a part of the *Orbitolina*-bearing rocks of the Second Defile and the neighbouring area." Since no further evidence has subsequently come to light, the matter must be left at that. If this inference is correct, and if the *Orbitolina*-bearing rocks of Tibet, the Hukawng Valley, and Burma are of the same age, then it follows that the Lower Cretaceous sea must have extended from Tibet across the northeastern part of Assam through the Hukawng Valley into Burma. On the western side, this sea apparently must have extended as far as Kashmir (see the discussion of that area above) and from there into Afghanistan (Clegg, 1941).

Very little is known of the geologic history of this region during the remainder of the Cretaceous period. In the Hukawng Valley, as already mentioned, the only Eocene rock observed to date is a conglomeratic limestone of Khirthar age (Middle Eocene). In central Burma, however, a very thick series of Eocene rocks, ranging in age from Ranikot to Khirthar (Paleocene to Upper Eocene), is developed. The rocks consist for the most part of an alternating series of sandstones and shales, with very subordinate impure limestones. The general succession (Tainsh, 1950, and Lepper, 1934) is shown in Table 9 (it is now realized that much of this will need revision). Little is known of the foraminifera in the lower portions, partly because the rocks themselves appear to be devoid of them in some sections, and partly perhaps because no careful search has been made. This is not the case, however, in the upper part of the succession.

Summarizing all of the available information concerning the age of the Axials, Cotter (1938, p. 37) states: "It must be concluded that the Axials are probably a complex of rocks of varying age, but it is possible that the great bulk of them may be pre-Cambrian, or perhaps comparable in age to such groups as the Simla slates and the Jaunsar series. The few fossiliferous beds seen may represent infolds of rocks of later age, including Triassic strata." Cotter records that Upper Cretaceous rocks occur between Tilin and Gangaw in a narrow, elongate strip faulted against the Yaw stage. He records the occurrence of "*Orbitoides*" *apiculata*, *Globigerina*, and some mollusks indicating a Maestrichtian age. A detailed examination of the rocks in this area would probably show the presence of other interesting foraminifera.

In Lower Burma, E. Lehner, during a traverse along the Prome-Taungup road, discovered beds of hard, compact porcellanic limestones not unlike the Parh limestone of Baluchistan, containing bi- and tricarinate forms of *Globotruncana*. Associated with these rocks there were also limestones of Ranikot age. The structure here is very complicated, and it was not possible to recognize the full succession represented in the area. These observations, and Cotter's discovery of typical Ranikot molluscan fossils in beds near the base of the Tertiary succession in the Pakokku District, as well as his report of the presence of beds of Danian age in the area, all tend to show that in Burma, too, a full sequence of rocks from the Lower Cretaceous to the Tertiary is present, but most of the Cretaceous and earliest Tertiary rocks are in regions of complicated structure. This factor makes it difficult to work out the correct sequence. Foraminiferal assemblages from the lower part of the Upper Cretaceous to the lower part of the Tertiary are fairly well known, and, if a careful examination of the area is made with adequate collection of samples, it should be possible not only to establish the correct sequence of rocks but also to unravel the structure. However, it is quite possible that all the rocks may not obligingly yield fossils, or, even when they do, the fossils may not be of diagnostic value.

On the Arakan Coast, Upper Cretaceous rocks containing *Globotruncana arca* (Cushman), *Globotruncana linneiana*, and *Globotruncana stuarti* are known from Ramree Island, unconformably underlying rocks of Middle Eocene age. Neither the full succession nor the actual thickness exposed can be ascersained easily, as the area is much faulted and disturbed. The Eocene rocks here contain typical *Assilina papillata*, *Nummulites obtusus*, *Nummulites perforatus* (Montfort), *Nummulites pengaronensis*, and several species of *Discocyclina*, some attaining 2 to 3 inches in diameter. The Cretaceous component of the Axials apparently continues southward into the

TABLE 9

EOCENE SUCCESSION IN CENTRAL BURMA

After Chibber (1934) and Tainsh (1950).

Stratigraphic division	*Lithology*	*Fauna*	*Age*
Pegu series			OLIGOCENE AND MIOCENE
Yaw shales (up to 2000′)	Blue-grey shales with some marly bands and foraminiferal limestones; carbonaceous sandy shales and sandstones with thin coal seams occur in some of the northern localities	*Nummulites yawensis*, *N. pengaronensis*, *Gypsina globula*, *Operculina*, *Discocyclina omphala*, etc.	UPPER EOCENE
Pondaung sandstone (up to 6000′)	Variegated clays, generally greenish when unweathered; greenish sandstones with conglomerate bands and subordinate shales	Mammalian fossils; some foraminifera; carbonized and silicified fossil wood, leaf impressions, and molluscan remains	UPPER EOCENE AND (?) MIDDLE EOCENE
Tabyin clays (up to 5000′)	Greenish conglomeratic shales interbedded with sandstones and some coal seams	*Nummulites acutus*, *N. atacicus*, and mollusca	MIDDLE EOCENE
Tilin sandstone (up to 4000′)	Mainly sandstones	Small *Nummulites*, shallow brackish to marine mollusca	LOWER EOCENE
Laungshe shales (up to 10,000′)	Thin-bedded blue clays, often concretionary and gypseous, with bands of sandstone	*Nummulites atacicus*, *Operculina*	LOWER EOCENE to PALEOCENE
Paunggy conglomerate (up to 3000′)	Inconsistent conglomerate bands, associated with grit beds and sandstones	*Discocyclina;* mollusca of Ranikot affinities	PALEOCENE

NOTE: Because of changes in facies, there is considerable variation in the lithologic character and thicknesses of these divisions; following group boundaries from one area to another therefore becomes extremely difficult. Much of the stratigraphy is also in need of revision.

Andaman Islands. Cotter (1938, p. 22) reported Cretaceous rocks underlying Eocene strata in the Andamans, and Gee (1926, p. 212) recorded *Assilina granulosa* from the Eocene rocks and suggested a Laki age for them. Tipper (1911, p. 205) recorded a complex group of red and yellow jaspers, quartzites, and pink and white porcellanic limestones forming the Cretaceous in the Andaman Islands. He regarded the porcellanic limestones as very similar to the "Lower Cretaceous" limestone [Parh limestone, now known to be Upper Cretaceous] of Baluchistan. No fossil evidence has been recorded from the porcellanic limestones, although there is every reason to believe that the correlation with the Parh limestone suggested by Tipper is very probable, since, as already stated, similar porcellanic limestones occurring between Prome and Taungup in the southern part of the Arakan Range (collected by Lehner) were found to contain bi- and tricarinate types of *Globotruncana*. According to Gee and Tipper, the Eocene consists of conglomerates, sandstones and clays. The sandstones are slightly micaceous.

Tipper (1911, pp. 198–199) recorded the Eocene fauna as poor, consisting of one species of *Nummulites* and one of *Assilina*; the former, however, is of wide occurrence. He identified the *Nummulites* as the common Indian Laki-Khirthar species *Num-*

mulites atacicus, and the *Assilina* as *Assilina granulosa*. Gee (1926, pl. 14, fig. 4) also recorded this species of *Assilina*, and his figure indicates that it is probably not *Assilina granulosa* but a form more closely related to the well known Khirthar species *Assilina papillata*. There is, therefore, some doubt concerning the Laki age of the Andaman Eocene rocks. Considering that in the Ramree Island area there is an unconformity between the Cretaceous and the Eocene and that the lowest Eocene in that area is of Khirthar age, and also considering the possibility that the Andaman outcrops form a continuation of the Ramree sequence, it is most important that the fossils of the Andaman Eocene be examined again to see if any further evidence is available.

Farther south, in Sumatra and other Indonesian islands, there seems to be a widespread unconformity between the Upper Cretaceous and the Lower Tertiary. The whole of the Paleocene and Lower Eocene (beds equivalent to the Ranikot and Laki) appear to be missing, and the Tertiary "*a*," the lowest local member of the Tertiary, is probably of Middle Eocene age (Glaessner, 1943, p. 55). Umbgrove (1947, p. 200 and text-fig. 122, p. 183) also supported this view, stating: "The region of the [East Indies] archipelago was probably an extensive land area at the end of the Mesozoic and the beginning of the Eocene." The structural trends from Sumatra continue into the Andaman and Nicobar Islands. Ramree Island lies on the northerly projection of the same trend. Although the available evidence is meagre, there seems to be a suggestion that the Ranikot sea did not reach as far west as Ramree Island, and was more or less limited to the eastern part of the Arakan Range. During Ranikot time, this range may have emerged sufficiently to separate the western basin from the eastern. On the west and south of the Arakan Range, a fairly continuous period of regression must have existed following the Cretaceous, which was broken only for a short time in the Andamans and in Ramree Island by the Khirthar (Middle Eocene) transgression. Farther south and southeast, however, this transgression was fairly continuous and widespread, and gave rise to the most interesting deposits of Tertiary "*a*" and "*b*" of the Indo-Pacific.

Reference should be made here to the report of *Miscellanea* and *Ranikothalia* in the Tertiary "*a*" (van der Vlerk, 1955). Both of these forms are typically Paleocene in India and Pakistan, and do not seem to fit in with the rest of the assemblage in the Tertiary "*a*," which is typically Middle and Upper Eocene in aspect. In 1955, while in the Netherlands, the writer had an opportunity, through the courtesy of Professor van der Vlerk, to examine the solitary slide containing the reported *Miscellanea*; this species is represented by one equatorial and one meridional section, which do not appear similar to those of any of the species of *Miscellanea* recorded from India, Pakistan, or the Middle East. On the other hand, the sections clearly show relationship with *Pellatispira* or a compressed rotaliid form such as *Calcarina*. As both sections represent a small form of the average size of rotaliid genera, the latter suggestion seems the more likely. It must be admitted, however, that the available material is insufficient to support a definite conclusion. It may be of interest to record here that forms not unlike these are very common at the top of the Prang limestone of central Assam. As the writer was not aware of the record of *Ranikothalia* at the time of his visit to the Netherlands, he could not check this form. On the whole, Glaessner's suggestion that the Tertiary "*a*" is probably of Middle Eocene age seems to be justified.

Except for the Yaw and Pondaung stages, the other Eocene stages of Burma have yielded only occasional foraminifera. Their age is established more by inference than by their characteristic faunas. Much work will be necessary to record the small foraminifera and perhaps the larger foraminifera also, that must be present in the more argillaceous and calcareous beds of the older Eocene stages from the Laungshe to the Tabyin.

The Yaw and Pondaung stages have yielded prolific foraminiferal assemblages of both smaller and larger foraminifera. Among the larger foraminifera are *Nummulites yawensis* (the Indo-Pacific relative of *Nummulites acutus* of the Tethyan province), a large *Gypsina* identified by Cotter as *Gypsina globulus* (Reuss), several species of *Pellatispira* commonly found in the Tertiary "*a*" and "*b*" of the Indonesian succession farther to the southeast, *Biplanispira*, several large discoidal forms of *Discocyclina*, *Asterigerina*, and others; *Nummulites pengaronensis* is also very common. Several species of *Operculina* peculiar to Burma and to localities farther southeast are present. Assilines and alveolines are absent (compare the Kopili stage of Assam).

The small foraminifera occur fairly abundantly in the Yaw shales but have not been studied critically. The loss of valuable collections in Burma during World War II makes such a study impossible until fresh collections can be made. However, it can be recorded here that some of the more common forms are *Ammobaculites*, *Anomalina*, *Bolivina*, *Cancris*, *Cibicides*, *Eponides*, *Globorotalia*, *Hantkenina (H.* cf. *alabamensis)*, *Lenticulina*, *Nonion*, *Planularia*, *Quinqueloculina*, and *Rotalia*.

Indian coastal areas

Marine Cretaceous development in the coastal areas is known in the Narbada Valley on the west, and on the Coromandal coast in the Trichinopoly and Pondicherry areas. A small development is present in Godavari District, near Rajamahendri. In the Pondicherry area and in the Narbada Valley a small development of Lower Tertiary rocks is also found.

In the Narbada Valley, Upper Cretaceous beds are present in a narrow stretch extending from Bagh (Gwalior) in the east to Baroda and Kathiawar. These rocks occur below the Deccan Trap, and near Bagh consist of:

Deccan Trap

Bagh beds	Coralline limestone
	Deola marl
	Nodular argillaceous limestone
	Nimar sandstone

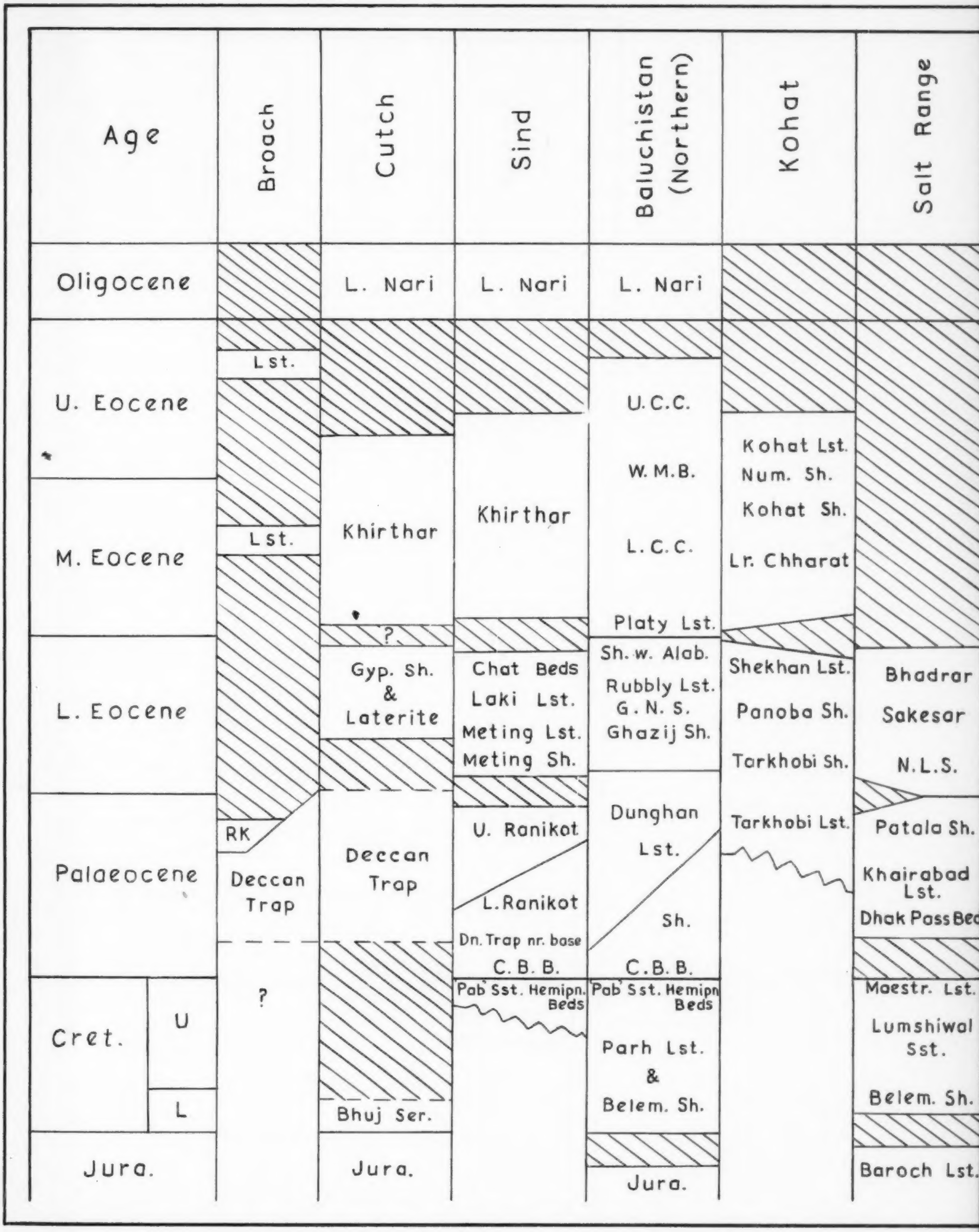
Metamorphics

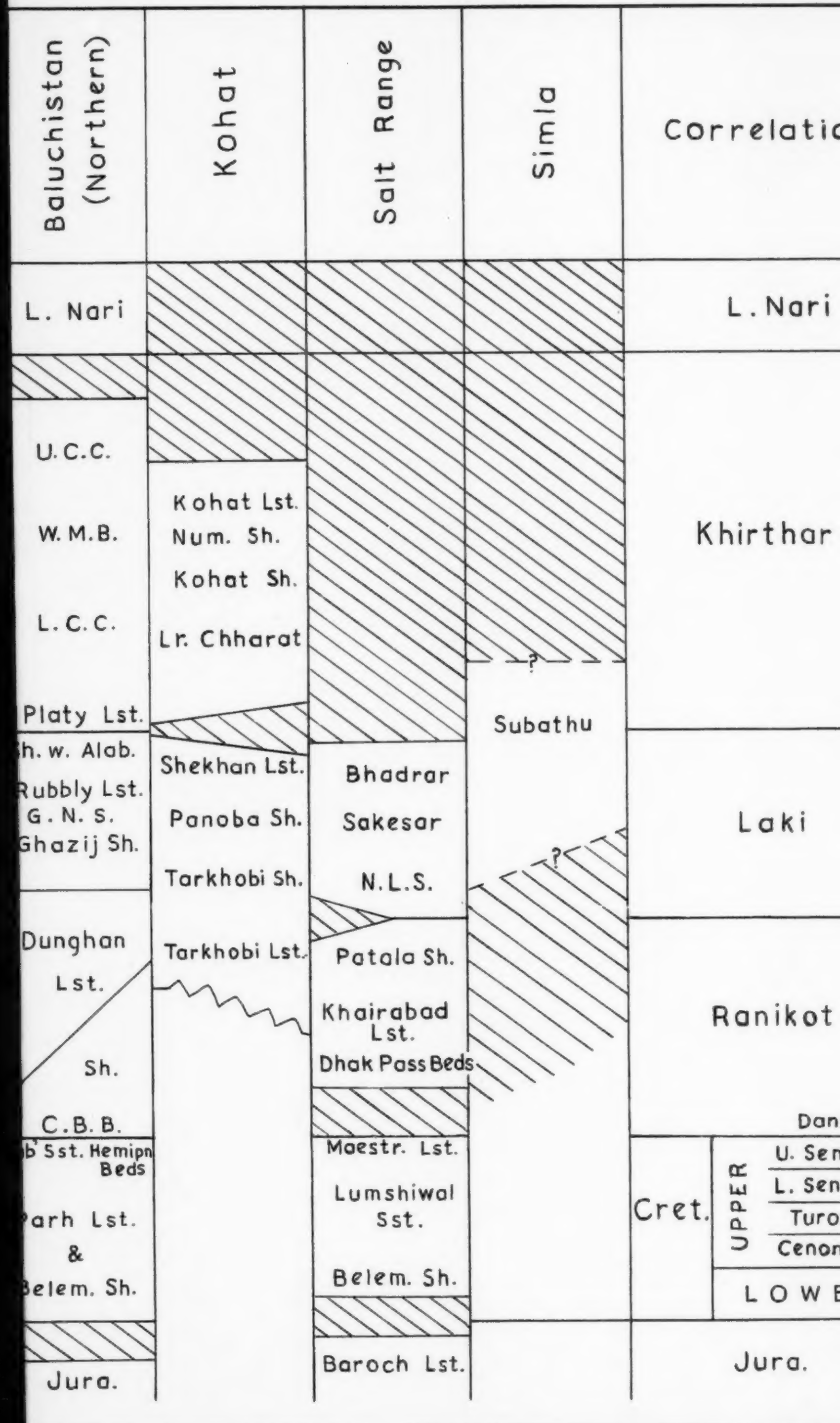
In this succession, only the three upper members of the Bagh beds are fossiliferous. Chiplonker (1938–1941) has examined this succession in detail, but the fossils described by him are all megafossils, including no foraminifera; he assigns these beds a Cenomanian to Turonian age. Here is another field which should prove very interesting in its foraminiferal fauna. Not much is known concerning any of the fauna, much less the foraminifera, of other localities in the Narbada Valley. Within the past few years, M. K. Roy Choudhuri and V. V. Sastri, of the Geological Survey of India, have done some work in this area, and it is hoped that the results of their examination will reveal the presence of foraminifera.

In the area between Surat and Broach there is a fair development of Lower Tertiary rocks overlying the Deccan Trap. One of the outcrops is 30 miles long and 12 miles wide, and it is believed that the maximum thickness exposed is of the order of 700 feet. The basal beds in this succession consist of impure foraminiferal limestones with *Ranikothalia nuttalli* (megalospheric form) and *Discocyclina* aff. *ranikotensis* Davies (Krishnan, 1956, p. 481). It should be noted that this is the southernmost record of Ranikot beds in the western areas. Overlying these Ranikot beds are some limestones with *Assilina exponens* and *Nummulites* cf. *beaumonti*, which can be correlated with the lower part of the Khirthar (Middle Eocene). The uppermost beds in the area contain *Pellatispira* and *Discocyclina* of Upper Eocene affinities. Beds of Laki age have apparently not been recognized to date. An earlier examination by S. R. N Rao (1941*a*) was confined to a few poorly exposed sections in Tarkeswar, Ghalha, and Kimamee, near the mouth of the Tapti. The succession examined by him (Rao, 1941*a*, pp. 7–8) consists of:

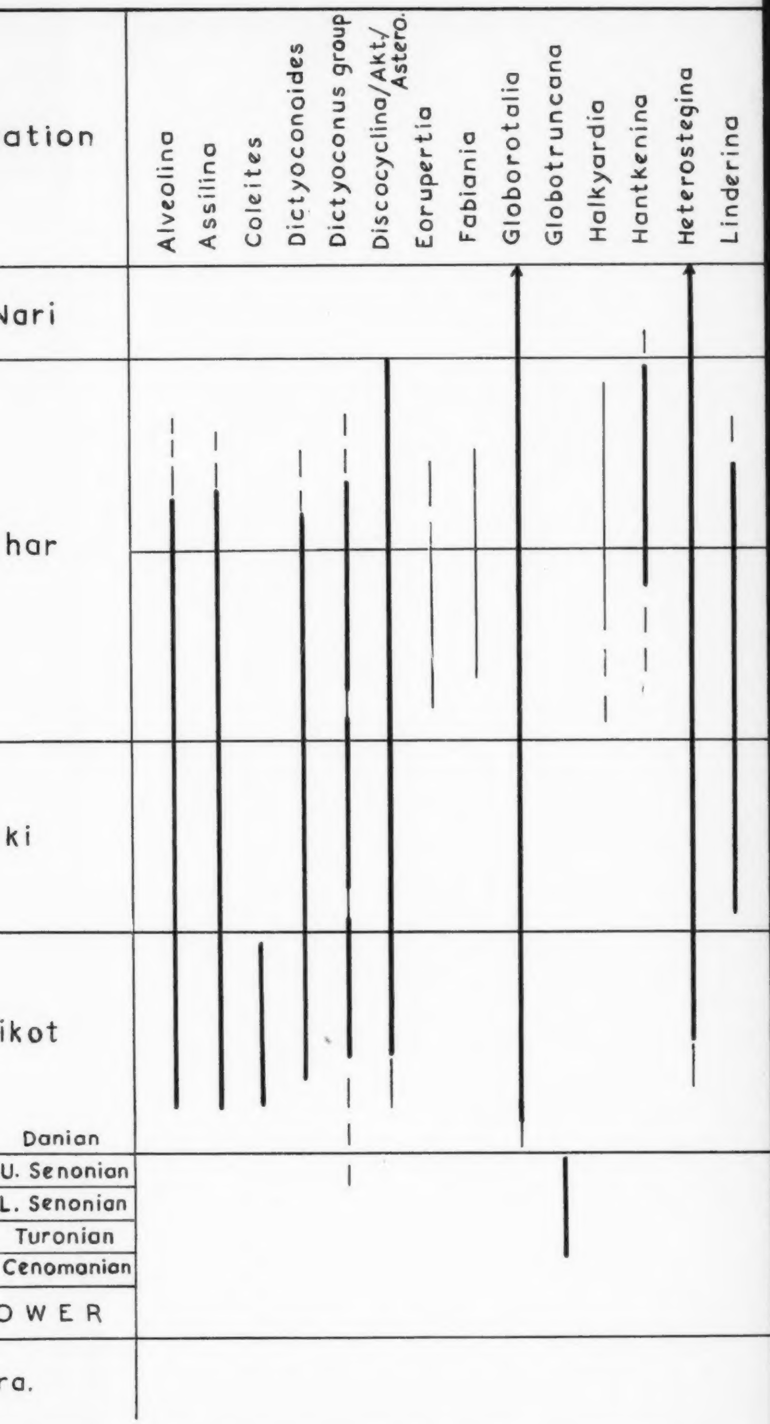
Upper Eocene	Hard yellow-brown foraminiferal limestone with *Pellatispira*, *Discocyclina*, etc.	8 ft.
	Ferruginous lateritic clay ..	1 ft.
Middle Eocene	Hard brown foraminiferal limestone with *Nummulites* and some mollusks	6 ft.
Lower(?) Eocene	Amygdaloidal trap	?

The Trichinopoly and Pondicherry areas have been receiving attention for over thirty years by L. Rama Rao and his associates at Mysore University. In these areas there is good development of the Upper Cretaceous, and it is known that foraminifera are present, in some cases in abundance. Since an early survey of the region by Blanford (1865) and a description of the prolific fauna by Stoliczka (1861–1873), no recent detailed survey of the area is available. The Geological Survey of India has done some work during the past three or four years, but their account has yet to be published. In spite of the interest taken by the Mysore University geological staff, their reports refer to very restricted areas only. It is clear, however, from such reports (a recent summary of all available information was made by Rama Rao in 1956) that a very interesting foraminiferal fauna exists in this area. A systematic study of the succession should be made, and samples for palaeontological examination should be collected at fairly short intervals. Such a study is necessary in order to understand the faunal evolution through the Upper Cretaceous and basal Tertiaries in this area and to discover the relationships of this coastal basin to the northern basins. Common foraminiferal faunules present in the Maestrichtian and Danian of other areas have already been shown to be present here. Overlying the Cretaceous rocks in the Pondicherry area there is a thin development of limestone that can be referred to the Paleocene. Foraminifera from this band include the genera *Ranikothalia* and *Discocyclina* (Rama Rao, Rao, and Nagappa, 1940). Furon (1941, p. 17) has indicated the presence of Middle Eocene rocks in some borings in the Pondicherry area. It therefore appears possible that an almost complete succession from the base of the Upper Cretaceous (perhaps even parts of the Lower Cretaceous are present) to at least about the Middle Eocene is present in this area.


Age
Broach
Cutch
Sind
Baluchistan (Northern)
Kohat
Salt Range
Oligocene
L. Nari
L. Nari
L. Nari
U. Eocene
Lst.
U.C.C.
W.M.B.
Kohat Lst.
Num. Sh.
Kohat Sh.
M. Eocene
Lst.
Khirthar
Khirthar
L.C.C.
Lr. Chharat
?
Platy Lst.
L. Eocene
Gyp. Sh. & Laterite
Chat Beds
Laki Lst.
Meting Lst.
Meting Sh.
Sh. w. Alab.
Rubbly Lst.
G. N. S.
Ghazij Sh.
Shekhan Lst.
Panoba Sh.
Tarkhobi Sh.
Bhadrar
Sakesar
N.L.S.
Palaeocene
RK
Deccan Trap
Deccan Trap
U. Ranikot
L. Ranikot
Dn. Trap nr. base
C.B.B.
Dunghan Lst.
Sh.
C.B.B.
Tarkhobi Lst.
Patala Sh.
Khairabad Lst.
Dhak Pass Bed
Cret.
U
L
?
Pab Sst. Hemipn. Beds
Pab Sst. Hemipn Beds
Parh Lst. & Belem. Sh.
Maestr. Lst.
Lumshiwal Sst.
Belem. Sh.
Bhuj Ser.
Jura.
Jura.
Jura.
Baroch Lst.


Baluchistan (Northern)
Kohat
Salt Range
Simla
Correlatio
L. Nari
U.C.C.
W.M.B.
L.C.C.
Platy Lst.
h. w. Alab.
Rubbly Lst.
G.N.S.
Ghazij Sh.
Dunghan Lst.
Sh.
C.B.B.
b Sst. Hemipn Beds
arh Lst. & Belem. Sh.
Jura.
Kohat Lst.
Num. Sh.
Kohat Sh.
Lr. Chharat
Shekhan Lst.
Panoba Sh.
Tarkhobi Sh.
Tarkhobi Lst.
Bhadrar
Sakesar
N.L.S.
Patala Sh.
Khairabad Lst.
Dhak Pass Beds
Maestr. Lst.
Lumshiwal Sst.
Belem. Sh.
Baroch Lst.
?
Subathu
?
L. Nari
Khirthar
Laki
Ranikot
Dan
Cret.
UPPER
U. Sen
L. Sen
Turo
Cenon
LOWE
Jura.

A OF THE CRETACEOUS – EOCENE SUCCESSION IN THE INDIA–PAKISTAN–BU



THE CRETACEOUS – EOCENE SUCCESSION IN THE INDIA–PAKISTAN–BURMA REGION

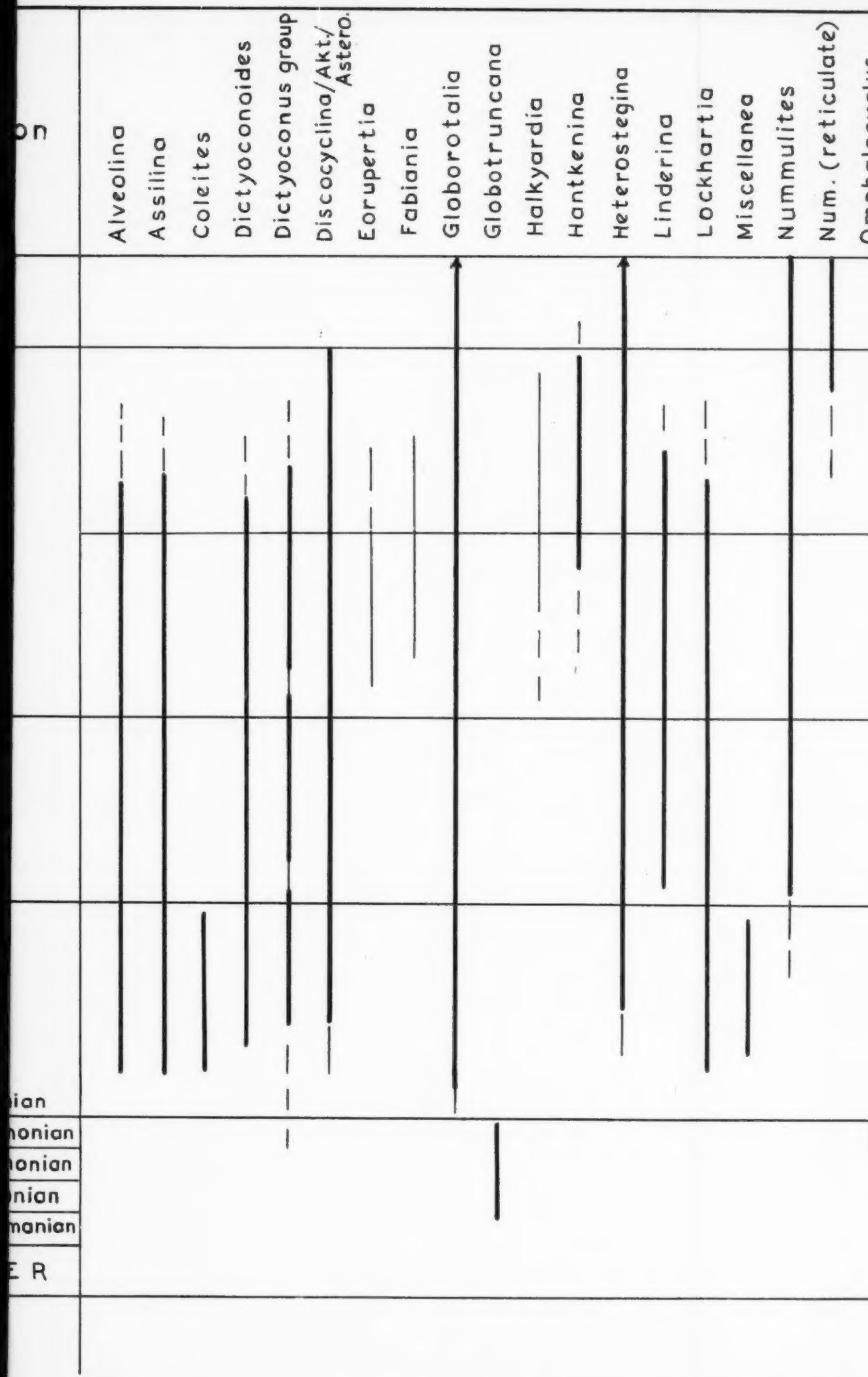
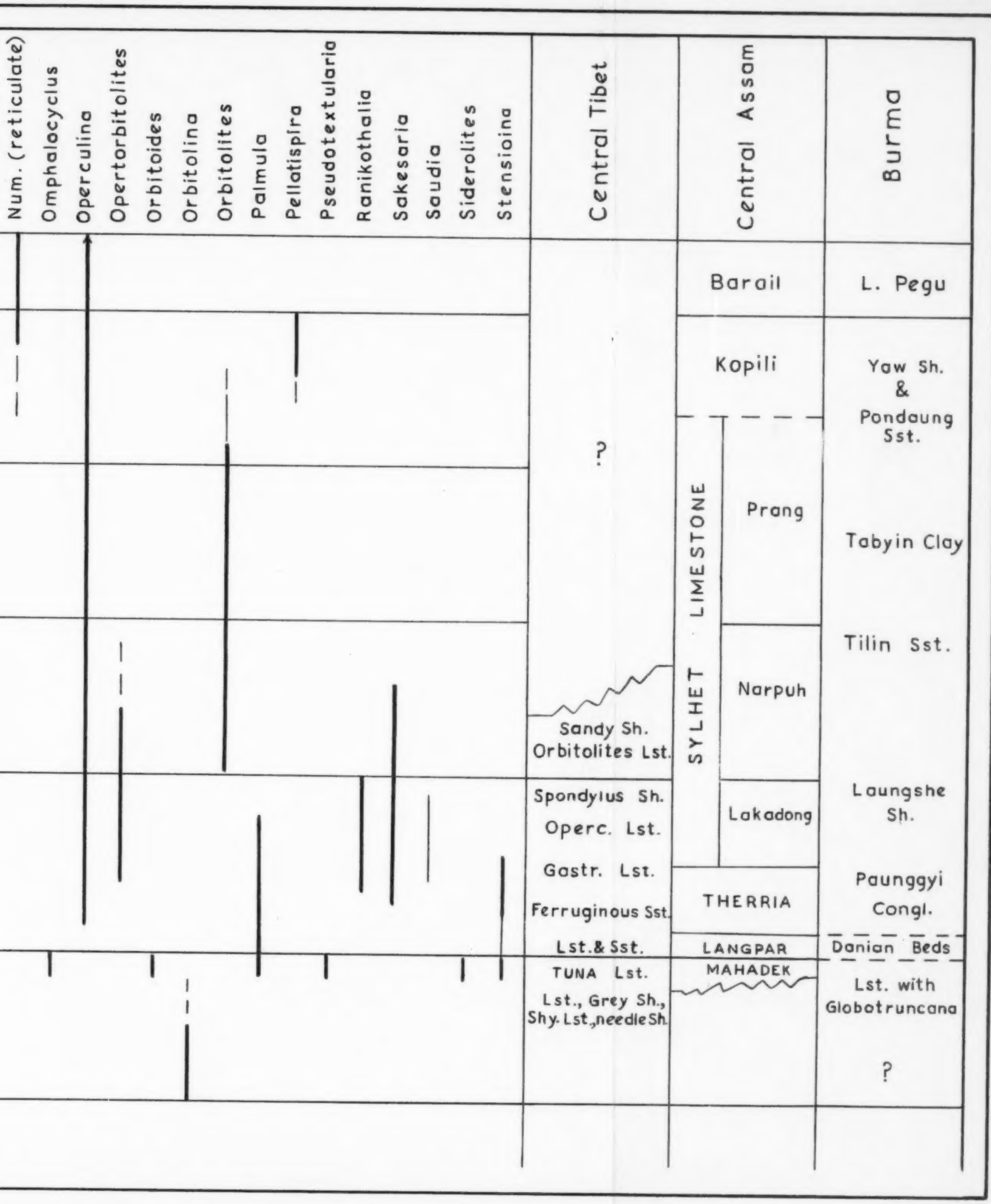


CHART 1


Num. (reticulate)
Omphalocyclus
Operculina
Opertorbitolites
Orbitoides
Orbitolina
Orbitolites
Palmula
Pellatispira
Pseudotextularia
Ranikothalia
Sakesaria
Saudia
Siderolites
Stensioina
Central Tibet
Central Assam
Burma
Barail
L. Pegu
Kopili
Yaw Sh. & Pondaung Sst.
?
Prang
Tabyin Clay
SYLHET LIMESTONE
Tilin Sst.
Narpuh
Sandy Sh. Orbitolites Lst.
Spondylus Sh.
Lakadong
Laungshe Sh.
Operc. Lst.
Gastr. Lst.
Paunggyi Congl.
THERRIA
Ferruginous Sst.
Lst.& Sst.
LANGPAR
Danian Beds
TUNA Lst.
MAHADEK
Lst. with Globotruncana
Lst., Grey Sh., Shy. Lst., needle Sh.
?

Some sedimentary rocks, apparently deposited in an estuarine facies, have been found in the Rajamahendri (Rajahmundry) area on the right bank of the Godavari. The rocks are greenish sandstones, and underlie the Deccan Trap. A thin fossiliferous band consisting of calcareous marl and limestone ranging in thickness from 2 to 14 feet occurs above the lowest flow of trap near Kateru and Pangadi. The fauna here is also believed to be estuarine. Some algae, including *Chara*, have been found, which tend to support this view. Foraminifera have been reported from these outcrops by S. R. N. Rao and K. S. Rao (1939), but the genera and species recorded include Miocene or post-Miocene forms, such as *Orbulina* cf. *universa* d'Orbigny and *Globorotalia* cf. *menardii* (d'Orbigny), in association with the typical Upper Cretaceous genus *Globotruncana*. The value of this report is therefore much reduced, and it will be necessary to re-examine the area. V. V. Sastri, of the Geological Survey of India, has found some Eocene Ostracoda in these Inter-trappean beds of Rajamahendri (see S. R. N. Rao, 1953).

SUMMARY AND CONCLUSIONS

The foregoing study suggests that during the Cretaceous, Paleocene, and Eocene, conditions of deposition were not uniform throughout the region. Several individual basins of deposition can be recognized, and yet the general picture shows an interrelated pattern of events whose synthesis leads to most interesting results. Such a synthesis clearly demonstrates the existence of definite cycles of transgression and regression in the region as a whole, which can serve as the basis for correlating the successions in the different areas. This synthesis is summarized in the following paragraphs.

The Lower Cretaceous is not very well known, but it must have witnessed the beginning of a transgression which, during the Upper Cretaceous, became an event of major importance in the entire region. Sporadic volcanic activity during the Lower Cretaceous, extending to some extent into the Upper Cretaceous, is evident in parts of Baluchistan and possibly also in the Rajmahal Hills, central Assam (the Sylhet and Mikir Hills traps), and in Myitkyina District in Upper Burma. The wide distribution of *Orbitolina*, although at present it is known only from scattered localities from Afghanistan through Baluchistan, Chikkim, and Tibet into Burma via the Hukawng Valley, points to a very extensive marine link. Perhaps this connexion extended through the Arakan Yoma into the Indonesian region, where there are many authentic records of similar forms of *Orbitolina*. As far as is now known, the *Orbitolina*-bearing rocks of India-Pakistan-Burma have yielded virtually nothing else of diagnostic value for age determination, and it is difficult to ascertain whether or not they are in part equivalent in age to the early *Globotruncana*-bearing beds of Cenomanian age. The Tibetan succession should be of considerable value in solving this problem.

According to Gignoux (1955), the large forms of *Orbitolina*, 1–5 cm. in diameter, are suggestive of a Cenomanian age, whereas the smaller ones (up to 1 cm.) belong to earlier ages, Barremian and Aptian. In most cases, these *Orbitolina*-bearing rocks represent "off-shore" continental-shelf deposits.

The above connexion between the Tethyan and Indo-Pacific provinces seems to have continued throughout the Upper Cretaceous, with its community of *Globotruncana* fauna. In some places (e.g., central Assam and Ramree Island), however, the marine transgression did not arrive until the beginning of the Maestrichtian. At the end of this stage a regression began which, in the Ramree group of islands and in the Andamans, produced an unconformity that extends well into the Laki. In Indonesia also, this interval is represented by an unconformity; the regression seems to have persisted at least until the end of the Lower Eocene. To the north, in Assam and Tibet, the regressive phase was short-lived and was very soon followed by the Paleocene transgression. On the west, the regression gave rise to the deposition of sandstones of varying thicknesses in Sind-Baluchistan, the Sulaiman Range (Pab sandstone), and the Samana Range (Hangu sandstone). In some places, there are either diastems or a condensed succession corresponding to this interval. In the western parts of Baluchistan, including southern Las Bela (the calcareous region of Vredenburg), deposition presumably was continuous, with pelagic limestone, shales, etc.

The regression discussed above is important because it appears to mark the Cretaceous-Tertiary boundary, and a careful study of events in various parts of the region reveals its presence in one form or another. In most of the areas in the region under study, and in other countries as well (see Nakkady, 1957; Reiss, 1954; and particularly Loeblich and Tappan, 1957), the horizon of maximum change in fauna, and perhaps in lithology too, appears to be at the end of the Maestrichtian. The Danian (for example, the *Cardita beaumonti* beds of Sind), where present, seems to represent the first phase of the Tertiary transgression, which was invariably followed by another regression before the main Paleocene (Ranikot) transgression set in. The Paleocene (Ranikot) sea had very wide geographic distribution, much beyond the limits indicated by Davies, but apparently

did not extend south of Broach-Surat on the west or south of Burma on the east. It thus stretched from the Mediterranean region on the west through Iraq, Iran, and the Persian Gulf area into western Pakistan; its continuation along the Himalayas has yet to be proved, but it certainly extended through Tibet and central Assam into Burma. On the west, an arm of this sea must have stretched southeastward from Sind across Cutch into Cambay as far south as Broach-Surat. Paleocene rocks are also present in the Pondicherry area of the South Indian east coast sedimentaries, and the Inter-trappeans of Rajamahendri may also be of this age. The connexion between the Tethyan sea and the Indo-Pacific across Assam still continued.

Toward the end of Ranikot time, a second regression is evident in most parts of this region. In Sind and Baluchistan, coal deposits were formed at this time, and in the Lakhi Range beds of laterite are present, suggesting terrestrial conditions. In Assam too, in the Khasi and Jaintia Hills, coal was formed at this period. In Burma also, this appears to have been a period of regression, being mainly represented by some of the Paunggyi conglomerates. The end of Ranikot time therefore marks another very important landmark in the geologic history of this region. In fact, it seems to be equally as important as the one at the end of the Maestrichtian. The Ranikot fauna, as is well known, is remarkably distinct and constant throughout the region, and stands out in strong contrast to the Laki-Khirthar fauna, on the one hand, and to that of the Maestrichtian on the other. A number of small foraminifera occurring in the argillaceous facies of the Ranikot have also been found in beds regarded as Danian in this subcontinent. There are also some new elements in the Danian fauna, whose affinities are yet to be investigated. However, in Sind as well as in Baluchistan, the first *Globorotalia* appears in the Danian. The occurrences, no doubt, are restricted to a few individuals, but, even so, their first appearance at this horizon is significant. The foregoing evidence, taken in conjunction with the complete absence of characteristic Upper Cretaceous genera and species such as *Globotruncana*, *Guembelina plummerae*, *Orbitoides*, *Pseudotextularia elegans* (Rzehak), and *Siderolites* in these Danian beds, clearly suggests a link with the Tertiary (basal Paleocene) for the Danian of this subcontinent. Further support for linking the Danian with the Paleocene is found in the occurrence of *Globigerina pseudobulloides* and *Globigerina triloculinoides* in beds not older than Danian and Ranikot ages. This same relationship is probably present in the east coast (Trichinopoly) succession. In the western part of the Arakan and the Andamans, as well as in Indonesia, the regression that began toward the end of the Cretaceous still continued. In some parts of Baluchistan and in the Salt Range, however, the regression at the end of the Ranikot seems to have been least felt.

By the end of Ranikot time, *Miscellanea* had become extinct. The small assilines that occur in the Ranikot are replaced in the Laki by larger and more variably ornamented types. Among the species of *Lockhartia* the typical Ranikot form *Lockhartia haimei* became extinct; the *Discocyclina* species are of the simple type and do not show much change, the common species of the type of *Discocyclina ranikotensis* occurring both in the Ranikot and the Laki. True *Nummulites* are rare or even absent in the Ranikot. In their place, *Ranikothalia* is present; this genus, however, does not appear to have survived the Ranikot.

A reasonably good nummulitic fauna developed with the beginning of Laki time. After the Ranikot stage the geologic history of the region witnessed two more important transgressions: (1) The lesser Laki transgression, and (2) the major Khirthar transgression, perhaps the most widespread of all the Lower Tertiary transgressions. The extent of the Khirthar transgression cannot be fully appreciated now, because in most of the marginal parts of the various basins where a return to marine conditions after the Khirthar was prevented by orogenic movements, the Khirthar has suffered denudation to a much greater extent than either the Ranikot or the Laki.

The Laki sea covered a fairly wide area, and was transgressive in Sind and Baluchistan, Kohat and the Salt Range, in the Himalayan region of Simla, and in Tibet. It was also transgressive in central Assam; in Burma, too, there was transgression, and a very thick group of argillaceous sediments (the Laungshe shales) were deposited at this period. Toward the end of Laki time there was again a widespread but short-lived regression. In parts of Sind, this is marked by an unconformity between the Laki and the Khirthar; in Kohat and the Potwar it is shown by the presence of an evaporite series with gypsum or gypsiferous shales. In Kohat, salt is associated with such evaporites. In central Assam and Burma, the regressive phase is not marked by any interruption in sedimentation but is clearly shown by the development of coarse-grained sandstones. In the Salt Range and a few other isolated areas, marine rocks younger than the Laki are not present.

As mentioned earlier, Khirthar time witnessed perhaps the most important and widespread of all the transgressions in the history of the Lower Tertiary of

the region. The Khirthar fauna is both rich and varied, with a large number of specialized forms. As has happened in other geologic times, such variety and specialization occur during periods of optimum conditions, ultimately resulting in the loss of characters that would enable a species to tolerate and survive normal changes in environmental conditions. Any environmental change which the less specialized forms would easily tolerate and survive is likely to cause wholesale extinction of the more specialized forms. The complicated septal filaments developed by some of the nummulites, the exquisite interseptal papillate ornamentation shown by the assilines of the *Assilina papillata-rota* suite, the variation in the size and shape of pillars and in the number of septa connecting them exhibited by the discocyclines, the large alveolines with their almost unlimited variation in the degree of "flosculinization," and the generally large size attained by most of these Khirthar forms indicate that the conditions were indeed most favourable for their living and multiplying. The assilines died out altogether well before the end of the Eocene, and were replaced by the genus *Pellatispira*; in the case of the nummulites, most of the very large and complex forms also died out before the end of the Eocene. A new race, the reticulate nummulites, came in about this time and continued into the Oligocene. Discocyclines did not survive the Eocene, nor did the alveolines of the type common during the Eocene. Obviously, the widespread regression at the end of the Eocene and the tectonic movements connected with it must have brought about these drastic faunal changes.

The area covered by the Khirthar sea stretches from the western Narbada Valley, south of Cambay, northwestward into Cutch and thence over most of Sind-Baluchistan into Kohat and the Potwar. East of Sind, it must have extended well into Rajasthan, as far as Jaisalmer and Bikaner, although in the latter area, at present, rocks younger than Laki in age are not exposed. Information is absent along the major part of the Himalayas, but in central Assam there is a fair development of Khirthar rocks. These rocks probably cover a large area under the alluvium or younger Tertiaries, at least in the upper Assam Valley and the Bengal basin, and possibly also in the Surma Valley. Stray occurrences of Khirthar rocks are present in the Hukawng Valley. Farther south, in central Burma, there is a long stretch of Upper Eocene Yaw-Pondaung rocks (perhaps extending down into the Middle Eocene) along the "Western Outcrops" which form the western margin of the Irrawaddy basin. On the Arakan Coast, in the Ramree Island area, and farther south, the Andamans, which had been unoccupied by the sea since the end of the Cretaceous, again were submerged during the Khirthar transgression.

In South India, the Khirthar transgression covered the Pondicherry area for a short while. Practically the whole of Indonesia also was overrun by this transgression, but apparently the connexion between the western Tethyan sea and the eastern Indo-Pacific sea at this period became slender, or at times even discontinuous. Although there is evidence of good continuity between central Assam and Burma, connexion to the west from Assam must have been intermittent. The development of rocks corresponding to the Kopilis of central Assam or to the Yaw Stage of Burma in western Pakistan and western India is limited (according to present knowledge) to a few localities; the thickness is also very small, less than 100 feet. Further work might reveal the presence of a greater development of these rocks. It is not improbable, however, that a part of the *Pellatispira*-bearing Yaw-Pondaung stages of Burma and of the Kopilis of Assam are represented in these western areas by rocks without *Pellatispira*. But, on the other hand, the development of *Pellatispira*-bearing beds in the Broach-Surat area seems to be related to the development of similar rocks in the Sulaiman Range rather than to the rocks of Cutch and Sind, though the latter area is nearer. These isolated outcrops were probably deposited in basins connected by a narrow gulf running across the Rajasthan desert and joining the Sulaiman deposits of this stage. During the Upper Eocene, there may have been a barrier along the western margin of this narrow gulf corresponding (approximately to the western margin of the present Cambay basin) which separated the two western areas of Cutch and Sind from the Tapti-Narbada area. In any case, there is evidence of fair distinction, but not entirely unmixed with some resemblance, between the Indo-Pacific faunas of Burma (Irrawaddy Basin) and the Indonesian basins of this period, on the one hand, and the Tethyan faunas of western Pakistan and western India on the other.

The position of Assam seems to be very important, since it exhibits characters of both the Tethyan and the Indo-Pacific provinces and thus forms a link between them. However, it is apparent from the foraminiferal faunas that there is a distinct leaning toward the Indo-Pacific. Some of the important Tethyan larger foraminifera are present here, but they show characters that are somewhat different from their typical examples in western Pakistan. *Nummulites obtusus*, for example, is represented in Assam by a race that has no pillars at all. *Nummulites acutus* shows

characters more akin to *Nummulites yawensis* of Burma. Certain types of *Operculina*, not present in western Pakistan but which are very common in Burma, are also present in the Kopilis of Assam. There are some large, thin discocyclines that recall similar forms in Burma. Their counterparts in western Pakistan seem to be absent. The Mollusca of the Kopilis show definite affinities with those of the Yaw stage of Burma and those of the Tertiary "*a*" and "*b*" of Java, most species being common, thus lending independent support to the evidence derived from the foraminifera.

The Tapti series, a subdivision suggested by Eames (1952*b*) for the highest Eocene rocks of western India and western Pakistan, is subject to critical examination. In the preceding paragraphs, a thesis has been developed indicating that each of the well known early Tertiary stratigraphic divisions of this region, the Ranikot, Laki, and Khirthar, began with a transgression and ended with a regression. If this thesis is correct, we might expect any new division of similar status to start with a transgression, indicating the beginning of a new cycle of deposition; if not, the only justification for regarding it as a major division would be an important change in the fauna.

The Tapti series of Eames was based on an analysis of the upper Chocolate clays fauna of the Rakhi Nala and Zinda Pir sections. The main evidence upon which this series was established appears to have been the presence of fossils of Upper Eocene age, particularly *Pellatispira*, in the upper part of these beds. Eames records (1952*b*, p. 192) that "the genus *Pellatispira*, occurring in local series IV, has never been unquestionably recorded anywhere from horizons as low as those containing the genus *Assilina*." In Indonesia, *Pellatispira* has been recorded from the Tertiary "*a*," where *Assilina* is also present. Tan Sin Hok (in Glaessner, 1943, p. 35) has stated that definite evidence for age distinction and superposition between beds with and without *Assilina* is lacking in Indonesia. Van der Vlerk (1955, p. 73) also is in agreement with this view. Although there is no reason to doubt Eames's evidence, a new series cannot be established for this reason alone. Divisions of the Gondwana do not conform strictly to European stages, nor do the divisions of the Pegu system in Burma. Regional history should form the basis of establishing stratigraphic divisions which are not of merely local status (see van Bemmelen, 1949). If we examine critically all of the evidence from the upper Chocolate clays of the Rakhi Nala and Zinda Pir, there is no event of major importance within this lithologic division. Sedimentation was continuous, and, as may happen in any such time interval, some newer faunal elements appeared in the younger beds. There is no abrupt change in the fauna, and all available evidence points to an uneventful continuity of conditions. On the other hand, a major event, that of rapid regression, took place at the end of this time period. The extent to which the Upper Eocene is developed, and its geographic distribution, are directly related to the time when this regression began in the various areas. The Khirthar in the India-Pakistan-Burma region is thus a series whose upper limit is not likely to be synchronous everywhere. There is no evidence, either within the upper Chocolate clays or elsewhere, for a division of series rank, and it will have to be accepted that the Khirthar as a whole represents both the Middle and the Upper Eocene of Europe. This idea fits in very well with the regional picture. It can also be recorded here that both Evans and Fermor, whose understanding of Indian geology certainly commands respect, doubted the wisdom of introducing this new series into the Eocene of this region (Eames, 1952*b*, pp. 197–198 and discussion).

At the end of the Eocene, even the interrupted connexion between the Tethyan and the Indo-Pacific was severed, and the subsequent history of the provinces was completely independent. There was merely a minor regressive phase at the end of the Eocene in the Irrawaddy basin, marked by the basal Pegu beds with their brackish-water to marine shoreline faunas. In upper Assam, the typically marine history of the Lower Tertiaries virtually came to an end with the Eocene; in western Pakistan, except for Sind, southern Baluchistan, and a small part of northern Baluchistan in the Bugti area, marine conditions in the Tertiaries came to an end with the Eocene. In Cutch, marine conditions continued into the Oligocene, with perhaps a minor break at the end of the Eocene as in Burma.

The general faunal succession in the subcontinent during the Cretaceous–Eocene interval, together with the approximate correlation of the strata in the various areas, is shown in Chart 1. It may be that, as more knowledge accumulates, the ranges of some of these species and genera will be extended, and some of the correlation will also need revision. It is hoped that the correlation submitted here will serve as a working basis for future investigations and will stimulate interest in this field of research.

The evolution of some of the common genera of larger foraminifera during the Eocene is shown in Charts 2–4, and here again they have been presented with a view to stimulating further investigations and should be regarded as purely tentative.

CHART 2
ASSILINA

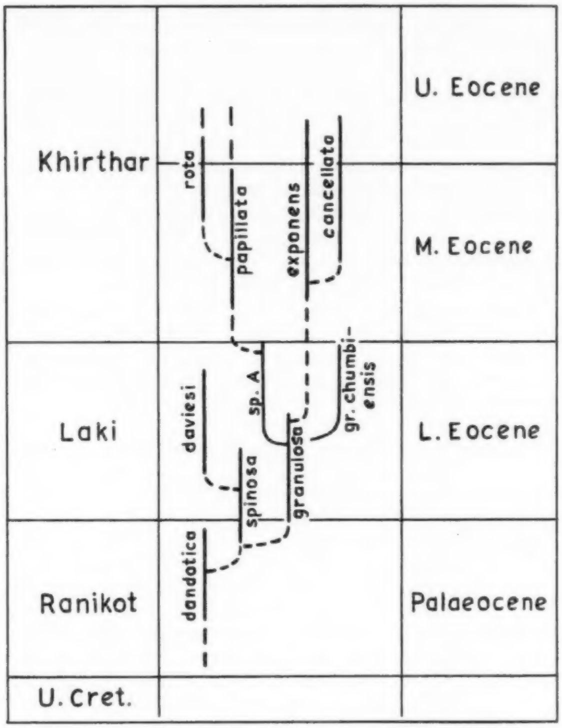
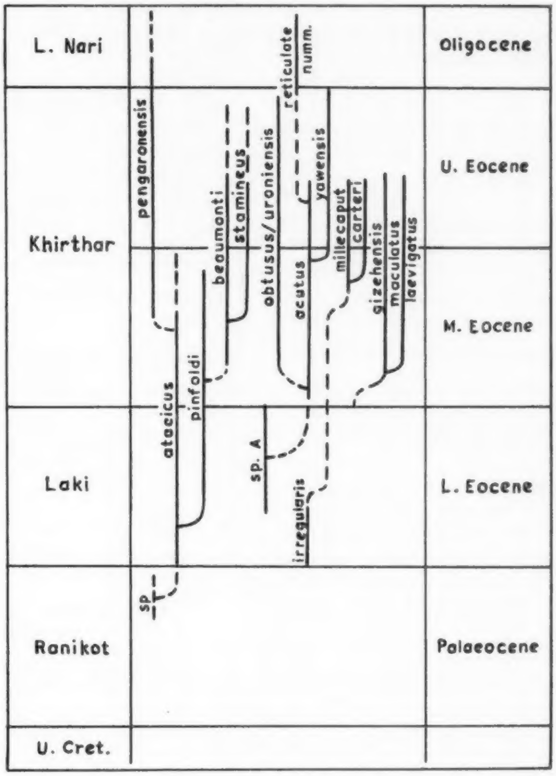


CHART 3
NUMMULITES



BIBLIOGRAPHY

ARCHIAC, A. D', AND HAIME, J.
1853 – *Description des animaux fossiles du groupe Nummulitique de l'Inde.* Paris: Gide et Baudry, pp. 1–373, pls. 1–36.

ARKELL, W. J.
1956 – *Jurassic geology of the world.* Edinburgh and London: Oliver & Boyd Ltd., pp. 385–387.

BEMMELEN, R. W. VAN
1949 – *The geology of Indonesia; Vol. 1A – General geology of Indonesia and adjacent archipelagoes.* The Hague: Netherlands Government Printing Office, 732 pp., ill.

BISWAS, B.
1954 – *On the occurrence of Hantkenina alabamensis from the Khasi Hills, Assam, India.* Jour. Pal., vol. 28, no. 6, pp. 791–795, pl. 94, text-fig. 1.

BLANFORD, H. F.
1865 – *On the Cretaceous and other rocks of south Arcot and Trichinopoly districts.* India, Geol. Survey, Mem., vol. 4, pt. 1.

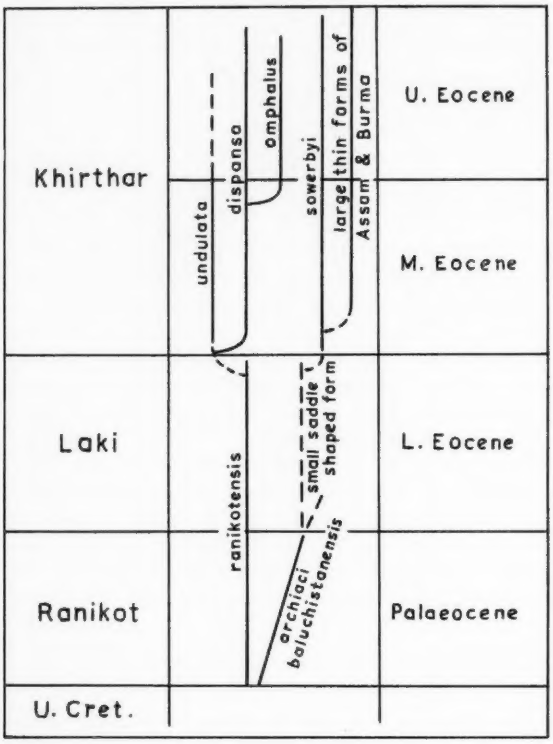
BLANFORD, W. T.
1876 – *On the geology of Sind.* India, Geol. Survey, Rec., vol. 9, pp. 8–22.
1878 – *On the geology of Sind.* India, Geol. Survey, Rec., vol. 11, pt. 2, pp. 161–173.
1879 – *The geology of western Sind.* India, Geol. Survey, Mem., vol. 17, pt. 1, pp. 1–197, pls. 1–6.

BOLLI, H.
1952 – *Note on the Cretaceous–Tertiary boundary in Trinidad, B.W.I.* Jour. Pal., vol. 26, no. 4, pp. 669–675, tables 1–3.

CARTER, H. J.
1844 – *Geological observations on the composition of the hills and alluvial soil from Hydrabad in Sindh, to the mouth of the River Indus.* Roy. Asiatic Soc., Bombay Branch, Jour., vol. 2, pp. 40–43, pls. 7–8, text-figs. 12–126.
1849 – *On foraminifera in Arabia, Sind, Kutch and Khattyawar.* Roy. Asiatic Soc. Bombay Branch, Jour., vol. 3, pp. 158–173, pl. 8.
1852 – *On the form and structure of the shell of Operculina arabica.* Ann. Mag. Nat. Hist., ser. 2, vol. 10, pp. 161–176, pl. 4.
1853 – *Description of some of the larger forms of fossilized foraminifera in Scinde, with observations on their internal structure.* Ann. Mag. Nat. Hist., ser. 2, vol. 11, pp. 161–177, pl. 7.
1854 – *On the true position of the canaliferous structure in the shell of fossil Alveolina (d'Orbigny).* Ann. Mag. Nat. Hist., ser. 2, vol. 14. pp. 99–101, pl. 3B.
1861 – *Further observations on the structure of foraminifera, and on the larger fossilized forms of Scinde, etc., including a new genus and species.* Ann. Mag. Nat. Hist., ser. 3, vol. 8, pp. 309–333, 366–382, 446–465, pls. 15–17.

CHART 4

DISCOCYCLINA



CHIBBER, H. L.
1934 – *The geology of Burma.* London: MacMillan & Co. Ltd.

CHIPLONKER, G. W.
1938 – *Rhynchonellids from the Bagh beds.* Indian Acad. Sci., Proc., sec. B, vol. 7, no. 6, pp. 300–316, 1 pl., 7 text-figs.
1939a *Echinoids from the Bagh beds.* Indian Acad. Sci., Proc., sec. B, vol. 9, no. 5, pp. 236–246, 1 pl.
1939b *Bryozoa from the Bagh beds.* Indian Acad. Sci., Proc., sec. B, vol. 10, no. 1, pp. 98–109, 2 pls.
1939c *Lamellibranchs from the Bagh beds.* Indian Acad. Sci., Proc., sec. B, vol. 10, no. 4, pp. 255–274, text-figs.
1941 – *Ammonites from the Bagh beds.* Indian Acad. Sci., Proc., sec. B, vol. 14, no. 3, pp. 271–276, 10 text-figs.

CITA, M. B.
1955 – *The Cretaceous–Eocene boundary in Italy.* World Petroleum Congr., IV, Proc., sec. 1/D, art. 2, pp. 427–452, text-fig. 1, sections 1–8.

CIZANCOURT, M. DE, AND COX, L. R.
1938 – *Contribution à l'étude des faunes Tertiaires de l'Afghanistan.* Soc. Géol. France, Mém., new ser., vol. 17, fasc. 1, no. 39, pp. 1–44, pls. 1–5.

CLEGG, E. L. G.
1937 – *Notes on the geology of the second defile of the Irrawaddy River.* India, Geol. Survey, Rec., vol. 71, pt. 4, pp. 350–359, pl. 28.
1938 – *The geology of parts of the Minbu and Thayetmyo districts, Burma.* India, Geol. Survey, Mem., vol. 72, pt. 2, pp. 137–317, pls. 12–17.
1941 – *The Cretaceous and associated rocks of Burma.* India, Geol. Survey, Mem., vol. 74, pt. 1, pp. 1–102, 20 pls.

COTTER, G. DE P.
1914 – *Notes on the value of Nummulites as zone fossils, with a description of some Burmese species.* India, Geol. Survey, Rec., vol. 44, pt. 1, pp. 52–84, pls. 1–3.
1926a *The distribution of the Gault in India.* India, Geol. Survey, Rec., vol. 59, pt. 4, pp. 405–409.
1926b *The age of the so-called Danian fauna from Tibet.* India, Geol. Survey, Rec., vol. 59, pt. 4, pp. 410–418.
1929 – *Some Orbitolinae from Tibet.* India, Geol. Survey, Rec., vol. 61, pt. 4, pp. 350–357, pls. 27–28.
1933 – *Geology of part of the Attock Dist., etc.* India, Geol. Survey, Mem., vol. 55, pt. 2, pp. 63–161, pls. 11–19.
1938 – *The geology of parts of the Minbu, Myingyan, Pakokku and lower Chindwin districts, Burma.* India, Geol. Survey, Mem., vol. 72, pt. 1.

COULSON, A. L.
1933 – *Geological notes on traverses in Tibet made by Sir Henry Hayden in 1922.* India, Geol. Survey, Rec., vol. 67, pt. 3, pp. 328–343, 1 text-fig.

DAVIES, L. M.
1925 – *Notes on the geology of Kohat, with reference to the homotaxial position of the Salt Marl at Bahadur Khel.* Asiatic Soc. Bengal, Jour. Proc., new ser., vol. 20 (1924), no. 6, pp. 207–224.
1926a *Remarks on Carter's genus Conulites.* India, Geol. Survey, Rec., vol. 59, pt. 2, pp. 237–253, pls. 16–20.
1926b *Remarks on the known Indian species of Conoclypeus.* India, Geol. Survey, Rec., vol. 59, pp. 358–368, pls. 25–26.
1926c *Notes on the correlation of Pinfold's Chharat series.* Mining and Geol. Inst. India, Trans., vol. 20, pls. 195–215.
1927a *The Ranikot beds at Thal (North-West Frontier Provinces of India).* Geol. Soc. London, Quart. Jour., vol. 83, pp. 260–290, pls. 18–22.
1927b *Supplement to notes on the correlation of Pinfold's Chharat series.* Mining and Geol. Inst. India, Trans., vol. 21, pp. 313–321.
1930a *The genus Dictyoconus and its allies.* Roy. Soc. Edinburgh, Trans., vol. 56, pp. 485–505, pls. 1–2.
1930b *The fossil fauna of the Samana Range and some neighbouring areas; Part 6 – The Palaeocene foraminifera.* India, Geol. Survey, Mem., Pal. Indica, new ser., vol. 15, pts. 1 and 6, pp. 67–79, pl. 10.
1932 – *The genera Dictyoconoides Nuttall, Lockhartia nov. and Rotalia Lamarck.* Roy. Soc. Edinburgh, Trans., vol. 57 (1934), pt. 2 (1932–1933), no. 13, pp. 397–428, pls. 1–4, text-figs. 1–10.
1935 – *The Eocene beds of the Punjab Salt Range.* Nature, vol. 135, p. 188.
1940 – *The upper Khirthar beds of north-west India.* Geol. Soc. London, Quart. Jour., vol. 96, pt. 2, pp. 199–230, pls. 9–12, 1 table.

DAVIES, L. M., AND PINFOLD, E. S.
1937 – *The Eocene beds of the Punjab Salt Range; Appendix: Correlation of the Salt Range beds with Eocene beds of Tibet.* India, Geol. Survey, Mem., Pal. Indica, new ser., vol. 24, no. 1, pp. 68–71.

DOUVILLÉ, H.
1916a *Le Crétacé et l'Éocène du Tibet central.* India, Geol. Survey, Mem., Pal. Indica, new ser., vol. 5, no. 3, pp. 1–84, pls. 1–16.
1916b *Les calcaires à orbitolines et à radiolites du Thibet.* In: HEDIN, S., *Southern Tibet, 1906–1908.* Stockholm: Norstedt, vol. 5, pp. 145–149, pls. 9–11.
1926 – *Fossiles recueillis par Hayden dans le Kashmir en 1906 et les Pamirs en 1914; leur description.* India, Geol. Survey, Rec., vol. 58, pt. 4, pp. 349–357.
1928 – *L'Éocène inférieur au Nord-Ouest de l'Inde, d'après les travaux du Major Davies.* Soc. Géol. France, C. R. Somm., no. 7, pp. 92–95, text-fig.

DROOGER, C. W.
1952 – *Foraminifera from Cretaceous–Tertiary transitional strata of the Hodna Mountains, Algeria.* Cushman Found. Foram. Res., Contr., vol. 3, pt. 2, pp. 89–103, pls. 15–16, text-figs. 1–3, table 1.

EAMES, F. E.
1952a *A contribution to the study of the Eocene in western Pakistan and western India: The geology of the standard sections in the western Punjab and in the Kohat district.* Geol. Soc. London, Quart. Jour., vol. 107, pt. 2, pp. 159–171.
1952b *Discussion of the faunas of certain standard sections, and their bearing on the classification and correlation of the Eocene in western Pakistan and western India.* Geol. Soc. London, Quart. Jour., vol. 107, pt. 2, pp. 173–196, 5 pls., 3 text-figs.

EVANS, P.
1932 – *Explanatory notes to accompany a table showing the Tertiary succession in Assam.* Mining and Geol. Inst. India, Trans., vol. 27, pt. 3, pp. 155–260.

EVANS, P., AND SANSOM, C. A.
1941 – *The geology of British oilfields; 3 – The oilfields of Burma.* Geol. Mag., vol. 78, pp. 321–350, 4 text-figs.

FEDDEN, F.
1879 – *On the distribution of the fossils described by Messrs. d'Archiac and Haime.* India, Geol. Survey, Mem., vol. 17, pp. 197–210.

FURON, R.
1941 – *Geologie de l'Inde Orientale Française.* France, Bur. Études Géol. et Minières Coloniales, Publ., no. 17, 26 pp., 2 pls., 4 text-figs., 1 table.

GEE, E. R.
1926 – *The geology of the Andaman and Nicobar Islands, with special reference to Middle Andaman Island.* India, Geol. Survey, Rec., vol. 59, pt. 2, pp. 205–232, pls. 11–15.
1944 – *The age of the Saline series of the Punjab and Kohat.* Nat. Acad. Sci. India, Proc., sec. B, vol. 14, pt. 6, pp. 269–311.
1946 – *Further note on the age of the Saline series of the Punjab and Kohat.* Nat. Acad. Sci. India, Proc., sec. B, vol. 16, pts. 2–4, p. 143, pl. 10.

GIGNOUX, M.
1955 – *Stratigraphic geology.* (English translation by Gwendolyn G. Woodford.) San Francisco, Calif.: W. H. Freeman & Co.

GILL, W. D.
1953 – *Facies and fauna in the Bhadrar beds of the Punjab Salt Range, Pakistan.* Jour. Pal., vol. 27, no. 6, pp. 824–844, pls. 88–91, text-figs. 1–4, tables.

GLAESSNER, M. F.
1943 – *Problems of stratigraphic correlation in the Indo-Pacific region.* Roy. Soc. Victoria, Proc., new ser., vol. 55, pt. 1, pp. 41–80, 1 chart.
1945 – *Principles of micropalaeontology.* Carlton, Victoria: Melbourne University Press, pp. vii–xvi, 3–296, pls. 1–14, text-figs. 1–64, tables.

GRIESBACH, C. L.
1893 – *On the geology of the country between the Chappar Rift and Harnai in Baluchistan.* India, Geol. Survey, Rec., vol. 26, pp. 113–147.

GRIMSDALE, T. F.
1951 – *Correlation, age determination, and the Tertiary pelagic foraminifera.* World Petroleum Congr., III (The Hague), Proc., sec. 1, pp. 463–475, 1 text-fig.
1952 – *Cretaceous and Tertiary foraminifera from the Middle East.* British Mus. (Nat. Hist.), Bull., Geol., vol. 1, no. 8, pp. 221–248, pls. 20–25, text-figs. 1–3.

HAQUE, A. F. M. M.
1956 – *The foraminifera of the Ranikot and the Laki of the Nammal Gorge, Salt Range.* Pakistan, Geol. Survey, Mem., Pal. Pakistanica, vol. 1, pp. 1–229, pls. 1–35.

HAYDEN, H. H.
1905 – *Preliminary note on the geology of the Provinces of Tsang and Ü in Tibet.* India, Geol. Survey, Rec., vol. 32, pp. 160–174.
1907 – *The geology of the Provinces of Tsang and Ü in central Tibet.* India, Geol. Survey, Mem., vol. 36, pt. 2, pp. 122–201.

HENNIG, A.
1916 – *Petrographie und Geologie.* In: HEDIN, S., *Southern Tibet, 1906–1908.* Stockholm; Norstedt, vol. 5, pp. 3–213, 11 pls., 21 tfs., 2 maps.

KOHLI, G., AND SASTRI, V. V.
1956 – *On the age of the Chikkim series.* Pal. Soc. India, Jour., vol. 1, no. 1, pp. 199–201, pls. 32–33.

KRISHNAN, M. S.
1953 – *General report for 1941 and 1942.* India, Geol. Survey, Rec., vol. 79, no. 1, pp. 270–272, 302–303.
1956 – *Geology of India and Burma.* Ed. 3. Madras: Higginbothams, pp. i–xiv, 1–555, pls. 1–22, text-figs. 1–14, tables 1–75, maps 1–13.

LAKHANPAL, R. N.
1954 – *Recognizable species of Tertiary plants from Damalgiri in the Garo Hills, Assam.* Palaeobotanist, vol. 3, pp. 27–32.

LA TOUCHE, T. H. D.
1893 – *Geology of the Sherani Hills.* India, Geol. Survey, Rec., vol. 26, no. 3, pp. 77–96.

LEPPER, G. W.
1934 – *Geology of the oil-bearing regions of the Chindwin-Irrawaddy Valley of Burma and of Assam-Arakan.* World Petroleum Congr. 1933, Proc., vol. 1, pp. 15–25.

LOEBLICH, A. R., AND TAPPAN, H.
1957 – *Correlation of the Gulf and Atlantic Coastal Plain Paleocene and Lower Eocene formations by means of planktonic foraminifera.* Jour. Pal., vol. 31, no. 6, pp. 1109–1137, text-figs. 1–5.

MULLER, S. W., AND SCHENCK, H. G.
1943 – *Standard of Cretaceous system.* Amer. Assoc. Petr. Geol., Bull., vol. 27, no. 3, pp. 262–278, 7 text-figs.

NAGAPPA, Y.
1951 – *The stratigraphical value of Miscellanea and Pellatispira in India, Pakistan and Burma.* Indian Acad. Sci., Proc., sec. B, vol. 33, no. 1, pp. 41–48.
1956 – *Foraminifera of the genera Fabiania and Eorupertia from the Sylhet limestone of Assam.* Pal. Soc. India, Jour., vol. 1, no. 1, pp. 191–198.

NAKKADY, S. E.
1955 – *The stratigraphical implication of the accelerated tempo of evolution in the Mesozoic–Cenozoic transitions of Egypt.* Jour. Pal., vol. 29, no. 4, pp. 702–706, text-figs. 1–5.
1957 – *Biostratigraphy and inter-regional correlation of the upper Senonian and Lower Paleocene of Egypt.* Jour. Pal., vol. 31, no. 2, pp. 428–447, text-figs. 1–3, table 1.

NOETLING, F.
1903 – *Übergang zwischen Kreide und Eocaen in Baluchistan.* Centralbl. Min. Geol. Pal., Jahrg. 1903, pp. 514–523, 1 tf.

NUTTALL, W. L. F.
1925*a* *The stratigraphy of the Laki series (Lower Eocene) of parts of Sind and Baluchistan.* Geol. Soc. London, Quart. Jour., vol. 81, pt. 3, pp. 417–453.
1925*b* *Two species of Eocene foraminifera from India.* Ann. Mag. Nat. Hist., ser. 9, vol. 16, pp. 378–388, pls. 20–21.
1926*a* *The larger foraminifera of the upper Ranikot series of Sind.* Geol. Mag., vol. 63, pp. 112–121, pls. 10–11.
1926*b* *The zonal distribution of the larger foraminifera of the Eocene of western India.* Geol. Mag., vol. 63, pp. 495–504.
1926*c* *The zonal distribution and description of the larger foraminifera of the middle and lower Khirthar series (Middle Eocene) of parts of western India.* India, Geol. Survey, Rec., vol. 59, pp. 115–164, pls. 1–8.
1931 – *The stratigraphy of the upper Ranikot series of Sind.* India, Geol. Survey, Rec., vol. 65, pp. 306–313.

OLDHAM, R. D.
1890 – *Report on the geology and economic resources of the country adjoining the Sind-Pishin railway between Sharigh and Spintangi, and of the country between it and Khattan.* India, Geol. Survey, Rec., vol. 23, pt. 3, pp. 93–110.
1892 – *Report on the geology of Thal Chotiali and part of the Mari country.* India, Geol. Survey, Rec., vol. 25, pt. 1, pp. 18–29.

PINFOLD, E. S.
1918 – *Notes on the structure and stratigraphy in the north-west Punjab.* India, Geol. Survey, Rec., vol. 49, pp. 137–160.
1939 – *The Dunghan limestone and the Creteaceous–Eocene unconformity in north-west India.* India, Geol. Survey, Rec., vol. 74, pt. 2, pp. 189–198.

RAJ NATH
1943 – *The Jurassic rocks of Cutch – Their bearing on some problems of Indian geology.* Indian Sci. Congr., 29th (1942), Proc., pt. 2, Presidential address, Section of Geology.

RAMA RAO L.
1939 – *On the occurrence of an Eocene bed in the Pondicherry Cretaceous area, S. India.* Current Science, vol. 8, no. 4, pp. 166–167, 1 text-fig.
1940 – *Recent advances in our knowledge of the Upper Cretaceous and Lower Eocene beds of India, with special reference to the Cretaceous–Eocene boundary.* Indian Sci. Congr., 27th, Proc., pt. 2, Presidential address, Section of Geology, pp. 105–145.
1956 – *Recent contributions to our knowledge of the Cretaceous rocks of south India.* Indian Acad. Sci., Proc., sec. B, vol. 44, no. 4, pp. 185–245, pls. 14–18, text-figs. 1–6.

RAMA RAO, L., RAO, S. R. N., AND NAGAPPA, Y.
1940 – *On Nummulites cf. thalicus Davies, from the Eocene bed in the Pondicherry area, South India.* Current Science, vol. 9, no. 8, p. 374, text-figs. 1-2.

RAO, K. S., AND RAO, S. R. N.
1939 – *The fossil Charophyta of the Deccan Inter-Trappeans near Rajahmundry.* India, Geol. Survey, Mem., Pal. Indica, new ser., vol. 29, no. 2.

RAO, S. R. N.
1941*a* *The Tertiary sequence near Surat and Broach (western India), with description of foraminifera of the genus Pellatispira from the Upper Eocene of this region.* Mysore Univ., Jour., new ser., sec. B, vol. 2, no. 1, pp. 5–17, pls. 1–2, 1 table.
1941*b* *Cretaceous orbitoids from the upper Ariyalur beds (Maestrichtian) of the Trichinopoly district, S. India.* Mysore Univ., Jour., new ser., sec. B, vol. 2, no. 2, pp. 61–66, pl. 6.
1953 – *News report: India.* Micropaleontologist, vol. 7, no. 1, p. 22.

RAO, S. R. N., AND TRIPATHI, B.
1950 – *Extension of the Maestrichtian sea into the Punjab Salt Range.* Current Science, vol. 19, no. 1, pp. 16–17.

REISS, Z.
1954*a* *On the Upper Cretaceous and Lower Tertiary microfaunas of Israel.* Israel, Res. Council, Bull., vol. 2, no. 1, pp. 37–50, 1 table.
1954*b* *Upper Cretaceous and Lower Tertiary Bolivinoides from Israel.* Cushman Found. Foram. Res., Contr., vol. 5, pt. 4, pp. 154–164, pls. 28–31, text-figs. 1–2.

ROY CHOUDHURY, M. K., AND SASTRI, V. V.
1954*a* *A note on the revised classification of the Cretaceous and the associated rocks of the Man River section of the lower Narbada Valley.* Science and Culture, vol. 20, no. 4, pp. 184–185.
1954*b* *On the geology of the Barwaha-Katkut area of the Narbada Valley in Madhya Bharat.* Science and Culture, vol. 20, no. 6, pp. 291–292.

SAHNI, M. R.
1937 – *Discovery of Orbitolina-bearing rocks in Burma; with a description of Orbitolina birmanica n. sp.* India, Geol. Survey, Rec., vol. 71, pt. 4, pp. 360–375, pls. 29–30.

SAID, R., AND KENAWY, A.
1956 – *Upper Cretaceous and Lower Tertiary foraminifera from northern Sinai, Egypt.* Micropaleontology, vol. 2, no. 2, pp. 105–174, pls. 1–7, text-figs. 1–6.

SMOUT, A. H.
1954 – *Lower Tertiary foraminifera of the Qatar Peninsula.* London: British Museum (Natural History), pp. iii–ix, 1–96, pls. 1–15, text-figs. 1–44, 1 table.

SOWERBY, J. DE C.
1840 – *Systematic description of organic remains from Cutch.* Geol. Soc. London, Trans., ser. 2, vol. 5, pp. 327–329, pls. 21–26.

SPITZ, A.
1914 – *A Lower Cretaceous fauna from the Himalayan Gieumal sandstone, together with a description of a few fossils from the Chikkim series.* India, Geol. Survey, Rec., vol. 44, pt. 3, pp. 197–224.

STOLICZKA, F.
1861–1873 – *Cretaceous fauna of southern India.* India, Geol. Survey, Mem., Pal. Indica, ser. 1 and 3, vol. 1; ser. 5, vol. 2; ser. 6, vol. 3; ser. 8, vol. 4.

1865 – *Geological sections across the Himalayan Mountains, from Wangtu bridge on the River Sutlej to Sungdo on the Indus, with an account of the formations in Spiti, accompanied by a revision of all known fossils from that district.* India, Geol. Survey, Mem., vol. 5, pt. 1, pp. 116–118, 143.

TAINSH, H. R.
1950 – *Tertiary geology and principal oil fields of Burma.* Amer. Assoc. Petr. Geol., Bull., vol. 34, pp. 823–855.

TIPPER, G. H.
1911 – *The geology of the Andaman Islands, with reference to the Nicobars.* India, Geol. Survey, Mem., vol. 35, pt. 4.

TROMP, S. W.
1949 – *The determination of the Cretaceous–Eocene boundary by means of quantitative, generic, microfaunal determinations and the conception "Danian" in the Near East.* Jour. Pal., vol. 23, no. 6, pp. 673–676.

UMBGROVE, J. H. F.
1938 – *Geological history of the East Indies.* Amer. Assoc. Petr. Geol., Bull., vol. 22, no. 1, pp. 1–70.

1947 – *The pulse of the earth.* Ed. 2. The Hague: Martinus Nijhoff, 358 pp., 8 pls., 204 text-figs., 12 tables.

VLERK, I. M., VAN DER
1955 – *Correlation of the Tertiary of the Far East and Europe.* Micropaleontology, vol. 1, no. 1, pp. 72–75.

VREDENBURG, E. W.
1906*a* *Nummulites douvillei, an undescribed species from Kachh, with remarks on the zonal distribution of Indian Nummulites.* India, Geol. Survey, Rec., vol. 34, pt. 2, pp. 79–95.

1906*b* *The classification of the Tertiary system in Sind with reference to zonal distribution of the Eocene Echinoidea described by Duncan and Sladen.* India, Geol. Survey, Rec., vol. 34, pt. 3, pp. 172–198.

1907 – *Note on the distribution of the genera Orthophragmina and Lepidocyclina in the Nummulitic series of the Indian Empire.* India, Geol. Survey, Rec., vol. 35, pp. 62–67.

1908 – *Cretaceous Orbitoides of India.* India, Geol. Survey, Rec., vol. 36, pt. 3, pp. 171–213.

1909*a* *Introductory note on the stratigraphy of the Ranikot series.* In: COSSMANN, M., AND PISSARRO, G., *The Mollusca of the Ranikot series.* India, Geol. Survey, Mem., Pal. Indica, new ser., vol. 3, no. 1, pp. v–xix.

1909*b* *Report on the geology of Sarawan Jhalawan, Mekran and the state of Las Bela.* India, Geol. Survey, Rec., vol. 38, pt. 3, pp. 189–215.

WADIA, D. N.
1928 – *The geology of Poonch State (Kashmir).* India, Geol. Survey, Mem., vol. 51, pt. 2.

1934 – *The Cambrian – Trias sequence of north-western Kashmir (parts of Muzaffarabad and Baramula districts).* India, Geol. Survey, Rec., vol. 68, pt. 2, pp. 121–176.

1935 – *On the Cretaceous and Eocene volcanic rocks of the Great Himalaya Range in northern Kashmir.* India, Geol. Survey, Rec., vol. 68, pt. 4, pp. 419–421.

1953 – *Geology of India.* MacMillan & Co. Ltd.

WADIA, D. N., AND DAVIES, L. M.
1929 – *The age and origin of the gypsum associated with the salt deposits of Kohat, North-West Frontier.* Mining and Geol. Ins t. India, Trans., vol. 24, pt. 2, pp. 202–222.

WARTH, H.
1895 – *Cretaceous formation of Pondicherry.* India, Geol. Survey, Rec., vol. 28, pp. 15–21.

WICHER, C. A.
1949 – *On the age of the higher Upper Cretaceous of the Tampico Embayment area in Mexico, as an example of the worldwide existance of microfossils and the practical consequences arising from this.* Belgrade, Mus. Hist. Nat. Pays Serbe, Bull., ser. A, no. 2, pp. 76–105, pls. 2, 3a–c, 4–8.

WILSON, G. F., AND METRE, W. B.
1953 – *Assam and Arakan.* In: ILLING, V. C. (ed.), *The world's oilfields: The Eastern Hemisphere.* (The Science of Petroleum, vol. 6, pt. 1). London: Oxford University Press, pp. 119–123.

WYNNE, A. B.
1872 – *Geology of Cutch.* India, Geol. Survey, Mem., vol. 9, pts. 1–2.

1878 – *On the geology of the Salt Range in the Punjab.* India, Geol. Survey, Mem., vol. 14.

EXPLANATION OF PLATES

PLATE 1

All figures × 10.

1 Thin section of Parh limestone, with mainly *Globotruncana appenninica* Renz, from Quetta, Baluchistan, western Pakistan; Cenomanian.

2 Thin section of Parh limestone, with mainly *Globotruncana lapparenti* Brotzen, from Kalat, Baluchistan, western Pakistan; stratigraphically higher than the limestone shown in figure 1; Turonian to lower Senonian.

3 Thin section of porcellanic limestone similar to the Parh limestone, with *Globotruncana* cf. *arca* Cushman, *Guembelina*, and *Globigerina*, from near the headwaters of Mufanow, Arakan Coast; upper Senonian.

4 Thin section of Dunghan limestone (basal part), with *Orbitoides media* (d'Archiac), from the Dunghan Range, Baluchistan, western Pakistan; Maestrichtian.

PLATE 2

All figures × 10.

1 Thin section of Dunghan limestone (basal part), with *Omphalocyclus macropora* (Lamarck) and *Siderolites calcitrapoides* Lamarck, from the Dunghan Range, Baluchistan, western Pakistan; Maestrichtian.

2 Thin section of sandy ferruginous limestone from near the top of the Mahadek stage, showing *Siderolites calcitrapoides* Lamarck, from near Cherrapunji, Khasi Hills, Assam (see text-fig. 11); Maestrichtian.

3 Thin section of brown impure limestone, with *Siderolites calcitrapoides* Lamarck, *Lepidorbitoides* sp., Bryozoa, and molluscan shell fragments, from the Ariyalur stage, Trichinopoly district; Maestrichtian.

4 Thin section of a limestone band in the *Cardita beaumonti* beds, showing molluscan shell fragments, small foraminifera (mainly *Guembelina* and *Globigerina*), from Bara Dome, Lakhi Range, Sind (see text-fig. 4); basal Paleocene (Danian).

PLATE 3

All figures × 10.

1 Thin section of dolomitized fine-grained limestone, showing a partially obliterated miliolid, from the Therria stage, Jaintia Hills, Assam (see text-fig. 11); Paleocene.

2 Thin section of dolomitized coarse-grained limestone, showing many badly altered fossils, from the Therria stage Jaintia Hills, Assam (see text-fig. 11); Paleocene.

3 Thin section of Ranikot limestone, with *Miscellanea miscella* (d'Archiac and Haime), *Alveolina* sp., *Discocyclina ranikotensis* Davies, *Ranikothalia thalica* (Davies), and *Ranikothalia* sp., from Zinda Pir, western Pakistan (see text-fig. 8); Upper Paleocene.

4 Thin section of algal limestone from the Lakadong stage, showing abundant *Distichoplax biserialis* (Dietrich), from near Cherrapunji, Khasi Hills, Assam (see text-fig. 11); Upper Paleocene.

PLATE 4

All figures × 10.

1 Thin section of limestone, with *Corallina grandis* (Das Cupta), *Distichoplax biserialis* (Dietrich), *Lockhartia haimei* (Davies), *Miscellanea miscella* (d'Archiac and Haime), and *Discocyclina* sp., from the Lakadong stage, Jaintia Hills, Assam (see text-fig. 11); Upper Paleocene.

2 Thin section of Laki limestone, with *Orbitolites complanatus* Lamarck, miliolids, and *Lituonella*, from Bara Dome, Lakhi Range, Sind, western Pakistan (see text-fig. 3); Lower Eocene.

3 Thin section of Laki limestone, with *Assilina* sp. *A* and *Nummulites*, from Bara Dome, Lakhi Range, Sind, western Pakistan (see text-fig. 3); Lower Eocene.

4 Thin section of limestone, with *Alveolina*, *Orbitolites complanatus* Lamarck, and miliolids, from the Umlatdoh stage, Therriaghat, Khasi Hills, Assam (see text-fig. 11); Lower Eocene.

PLATE 5

All figures × 10.

1 Thin section of Khirthar limestone, with *Assilina cancellata* Nuttall, *Nummulites pengaronensis* Verbeek, *Discocyclina* spp., etc., from Las Bela, Sind, western Pakistan; Middle Eocene.

2 Thin section of limestone, with *Assilina papillata* Nuttall, *Nummulites beaumonti* d'Archiac and Haime, etc., from the lower part of the Prang stage, Jaintia Hills, Assam (see text-fig. 11); Middle Eocene.

3 Thin section of limestone, with *Discocyclina sowerbyi* Nuttall, *Nummulites pengaronensis* Verbeek, etc., from the upper part of the Prang stage, Jaintia Hills, Assam (see text-fig. 11); Upper Eocene.

4 Thin section of limestone with *Pellatispira madaraszi* Hantken var. *indica* Rao, *Discocyclina omphala* Fritsch, and *Discocyclina* sp., from the Kopili stage, Jaintia Hills, Assam (see text-fig. 11); Upper Eocene.

PLATE 6

In all except figure 1, a = dorsal view; b = ventral view; c = side view.

1 Thin section of limestone, × 10, with *Pellatispira glabra* Umbgrove, from the Yaw stage, South Bassein area, Burma (see Table 9); Upper Eocene.

2–4 *Globotruncana appenninica* Renz
2, × 60, from the Pabuni group, Las Bela, western Pakistan; 3, × 80, from the Parh limestone, Kalat, western Pakistan; 4, × 80, from the Belemnite shales, Quetta, western Pakistan; all Cenomanian.

5 *Globotruncana stephani* Gandolfi
Pabuni group, Las Bela, western Pakistan; Turonian; × 60.

6 *Globotruncana linneiana* (d'Orbigny)
Kalat, western Pakistan; Senonian; × 80.

7–10 *Globotruncana lapparenti* Brotzen
7, 9, × 80, from the Parh limestone, Kalat, western Pakistan; 8, × 80, from the Parh limestone, Quetta western Pakistan; 10, × 60, from the Pabuni group, Las Bela, western Pakistan; all Senonian.

PLATE 7

In figures 1 and 13–17, a = dorsal view; b = ventral view; c = side view.

1–3 *Globotruncana stuarti* (de Lapparent)
1, × 60, from the Mahadek stage, Therriaghat, Assam (see text-fig. 11) (Maestrichtian); 2, × 80, from the Parh limestone, Quetta, western Pakistan (upper Senonian); 3, × 80, from the Parh limestone, Kalat, western Pakistan (upper Senonian).

4 *Guembelina striata* (Ehrenberg)
Korara shales, Las Bela, western Pakistan; Maestrichtian; × 130.

5–6 *Guembelina plummerae* Loetterle
5, peripheral view; 6a, side view; b, peripheral view; both from the Mahadek stage, Therriaghat, Assam (see text-fig. 11); Maestrichtian; × 60.

7–8 *Pseudotextularia elegans* (Rzehak)
a, side view; b, apertural view; both from the Mahadek stage, Therriaghat, Assam (see text-fig. 11); Maestrichtian; × 60.

9–10 *Bolivina incrassata* Reuss
Mahadek stage, Therriaghat, Assam (see text-fig. 11); Maestrichtian; × 130.

11–12 *Guembelina globulosa* (Ehrenberg)
a, side view; b, peripheral view; both from the Langpar stage, Khasi Hills, Assam (see text-fig. 11); Danian; × 130.

13 *Globigerina triloculinoides* Plummer
Langpar stage, Khasimara, Khasi Hills, Assam (see text-fig. 11); Danian; × 130.

14 *Globigerina pseudobulloides* Plummer
Langpar stage, Therriaghat, Assam (see text-fig. 11); Danian; × 130.

15 *Cibicides alleni* (Plummer)
Langpar stage, Therriaghat, Assam (see text-fig. 11); Danian; × 60.

16 *Globorotalia* sp.
Lower Rakhigaj shales, Rakhi Nala, western Pakistan (see Table 5 and text-fig. 8); Upper Paleocene; × 130,

17 *Gyroidina girardana* (Reuss)
Langpar stage, Khasimara, Khasi Hills, Assam (see text-fig. 11); Danian; × 60.

PLATE 8

1 *Globorotalia* cf. *velascoensis* (Cushman)
a, dorsal view; b, ventral view; c, side view; lower Rakhigaj shales, Rakhi Nala, western Pakistan (see Table 5 and text-fig. 8); Upper Paleocene; × 60.

2–3 *Discocyclina ranikotensis* (Davies)
2, equatorial section; 3, meridional section; both from the Nammal limestones and shales, Salt Range, western Pakistan (see text-fig. 10); Lower Eocene; × 10.

4–6 *Assilina granulosa* (d'Archiac)
4–5, equatorial sections of megalospheric and microspheric forms from the Tarkhobi shales, Tarkhobi, western Pakistan (see Table 6); 6, meridional section of microspheric form from the Laki limestone, Bara Dome; western Pakistan (see text-fig. 3); all Lower Eocene; × 7.

7–10 *Nummulites irregularis* Deshayes
7, 10, equatorial sections of megalospheric and microspheric forms from the Tarkhobi shales (*Irregularis* bed), Tarkhobi-Panoba, western Pakistan (see Table 6); 8–9, equatorial and meridional sections of megalospheric forms from the Nammal limestones and shales, Salt Range, western Pakistan (see text-fig. 10); all Lower Eocene; × 5.

11–14 *Assilina* sp. *A*
11–12, equatorial and meridional sections of microspheric forms; 13–14, equatorial and meridional sections of megalospheric forms; all from the green and nodular shales, Rakhi Nala, western Pakistan (see Table 5); Lower Eocene; × 7.

15–17 *Nummulites beaumonti* d'Archiac and Haime
15–16, equatorial and meridional sections, × 5, of microspheric forms from the Crab marls, Bugti, western Pakistan (Upper Eocene); 17, equatorial section, × 7, of microspheric form from the Prang stage, Therriaghat, Assam (see text-fig. 11) (Middle Eocene).

PLATE 9

1–2 *Nummulites beaumonti* d'Archiac and Haime
Equatorial and meridional sections, × 10, of megalospheric forms from the Prang stage: 1, from the Garo Hills, Assam (Upper Eocene); 2, from the Jaintia Hills, Assam (see text-fig. 11) (Middle Eocene).

3–4 *Nummulites obtusus* (Sowerby)
3, meridional section; 4, equatorial section; both from the Khirthar limestone, Watawaro, Sind, western Pakistan; Middle Eocene; × 5.

5–7 *Nummulites obtusus* (Sowerby) var.
5, equatorial section; 6, meridional section; 7, lateral section to show septal filaments; all from the Prang stage Lubha River, Jaintia Hills, Assam (see text-fig. 11); Upper Eocene; × 6.

8–9 *Nummulites acutus* (Sowerby)
Equatorial and meridional sections, × 10, of megalospheric forms from the Prang stage: 8, from the Norang River, Garo Hills, Assam; 9, from the Mikir Hills, Assam (see text-fig. 11); both Upper Eocene.

10 *Halkyardia minima* (Liebus)
Thin section in rock, × 85, from the Prang stage, Prang River, Jaintia Hills, Assam (see text-fig. 11); Middle Eocene.

11–12 *Nummulites yawensis* Cotter
11, equatorial section; 12, meridional section; both from the Yaw stage, Kyetubok, Burma (see Table 9); Upper Eocene; × 4.

13 *Cibicides perlucidus* Nuttall
a, dorsal view; b, ventral view; c, side view; Kopili stage, Maheshkhali, Garo Hills, Assam (see text-fig. 11); Upper Eocene; × 60.

PLATE 10

1–2 *Nummulites acutus* (Sowerby)
Equatorial and meridional sections, × 6, of microspheric forms from the Prang stage, Norang River, Garo Hills, Assam (see text-fig. 11); Upper Eocene.

3–5 *Nummulites pengaronensis* Verbeek
3, equatorial section, × 7½, of microspheric form; 4, meridional section, × 10, of microspheric form; 5, equatorial section, × 10, of megalospheric form; all from the Kopili stage, Jaintia Hills, Assam (see text-fig. 11); Upper Eocene.

6–8 *Discocyclina dispansa* (Sowerby)
6, equatorial section, × 10, of microspheric form from the white marl band, Rakhi Nala, western Pakistan (see Table 5); 7, central part of equatorial section, magnified × 600 to show the initial stage, of microspheric form from the upper chocolate clays, Rakhi Nala, western Pakistan (see Table 5); 8, meridional section, × 10 of microspheric form from the white marl band, Shirani, western Pakistan; all Middle Eocene.

9–10 *Discocyclina undulata* Nuttall
9, equatorial section; 10, meridional section; both from the upper chocolate clays, Rakhi Nala, western Pakistan (see Table 5); Middle Eocene; × 10.

11 *Cancris* cf. *mauryae* Cushman and Renz
a, dorsal view; b, ventral view; c, side view; Kopili stage, Garo Hills, Assam (see text-fig. 11); Upper Eocene; × 60.

12–13 *Guembelina venezuelana* Nuttall
a, side view; b, peripheral view; both from the Kopili stage, Garo Hills, Assam (see text-fig. 11); Upper Eocene; × 130.

PLATE 11

1–2 *Discocyclina sowerbyi* Nuttall
1, equatorial section, × 4, of microspheric form from the Prang stage, Therriaghat, Assam; 2, equatorial section, × 8, of megalospheric form from the Kopili stage, Lubha River, Jaintia Hills, Assam (see text-fig. 11); both Upper Eocene.

3–5 *Discocyclina omphala* (Fritsch)
3, meridional section, × 6, of microspheric form; 4–5, equatorial and meridional sections, × 10, of megalospheric forms; all from the Kopili stage, Lubha River, Jaintia Hills, Assam (see text-fig. 11); Upper Eocene.

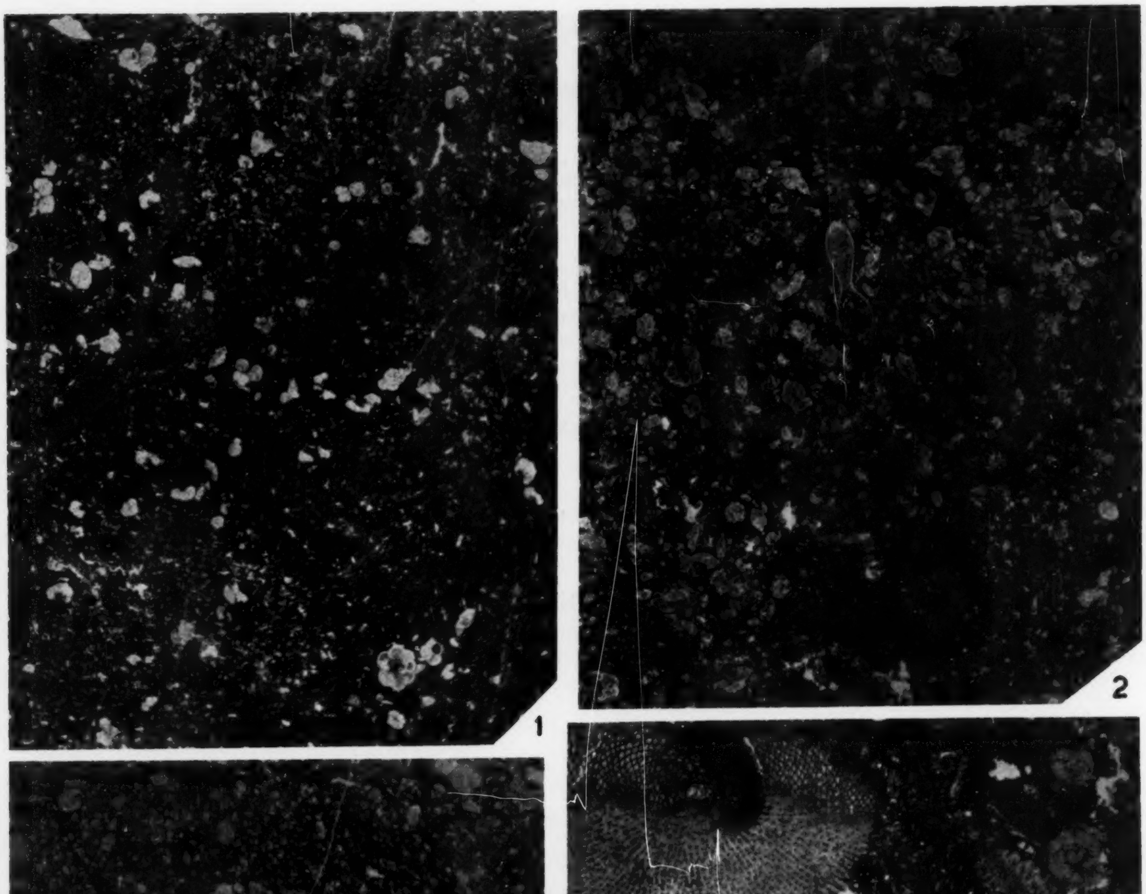
6–9 *Pellatispira glabra* Umbgrove
6, 9, equatorial and meridional sections of microspheric forms from the Jaintia Hills, Assam; 7–8, equatorial sections of megalospheric forms from Therriaghat, Assam (see text-fig. 11); all from the Kopili stage, Upper Eocene; × 10.

10–12 *Pellatispira inflata* Umbgrove
10, 12, equatorial and meridional sections of microspheric forms; 11, equatorial section of megalospheric form; all from the Kopili stage, Khasimara, Khasi Hills, Assam (see text-fig. 11); Upper Eocene; × 10.

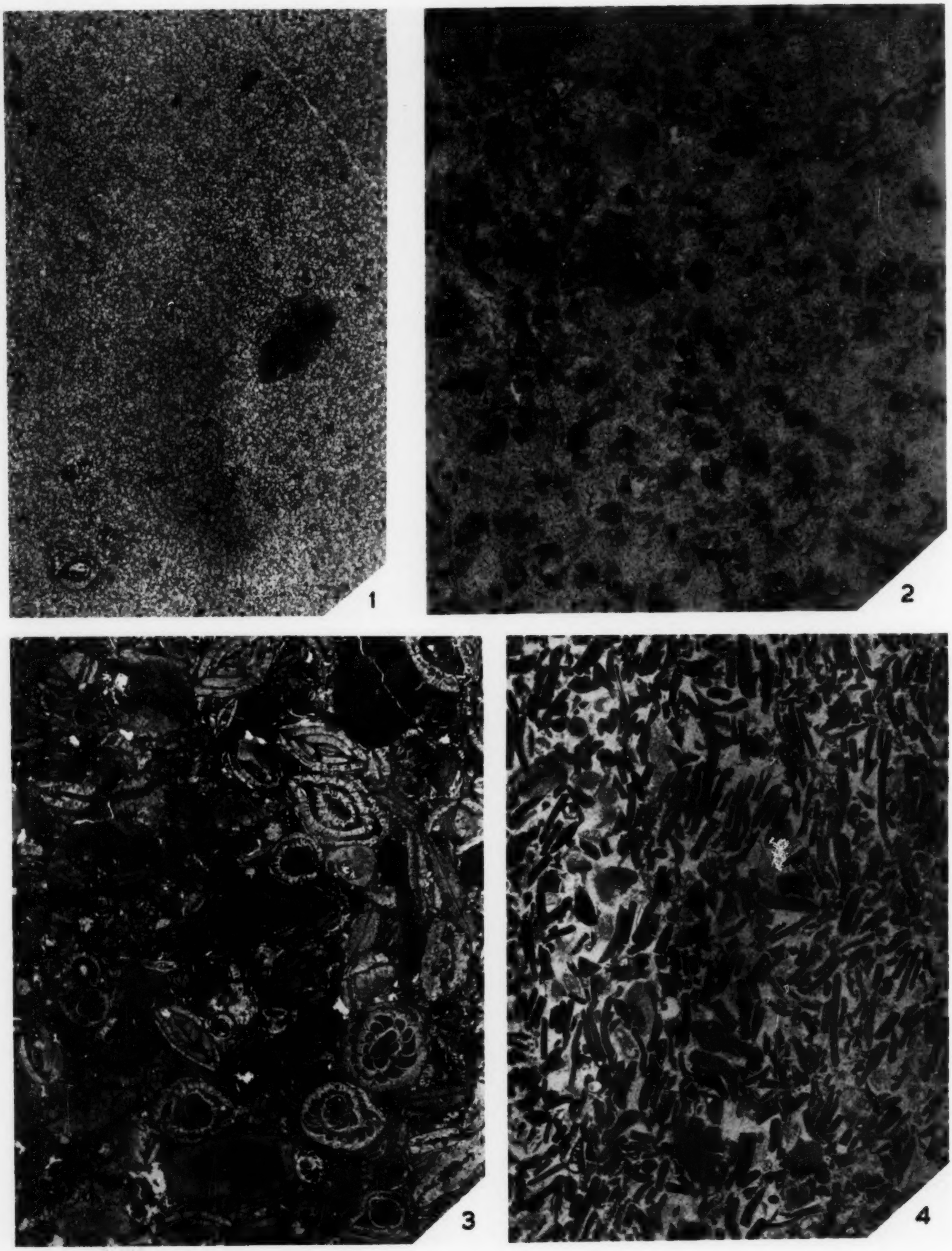
13 *Gypsina globula* (Reuss)
Thin section, × 9, from the Yaw stage, Kyetubok, Burma (see Table 9); Upper Eocene.

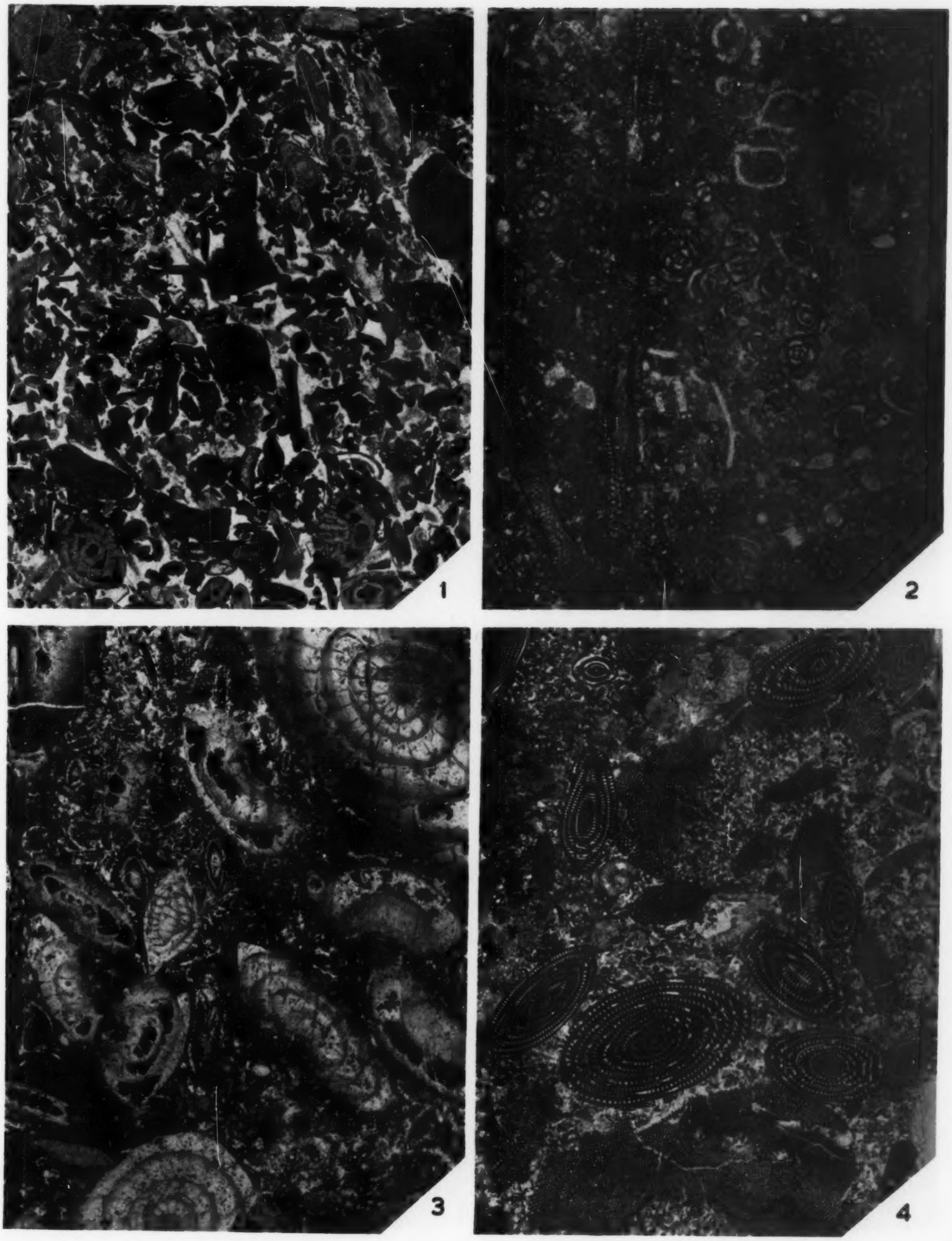
14 *Hantkenina alabamensis* Cushman
a, side view; b, edge view; Kopili stage, Dalu-Tura road, Garo Hills, Assam (see text-fig. 11); Upper Eocene; × 130.

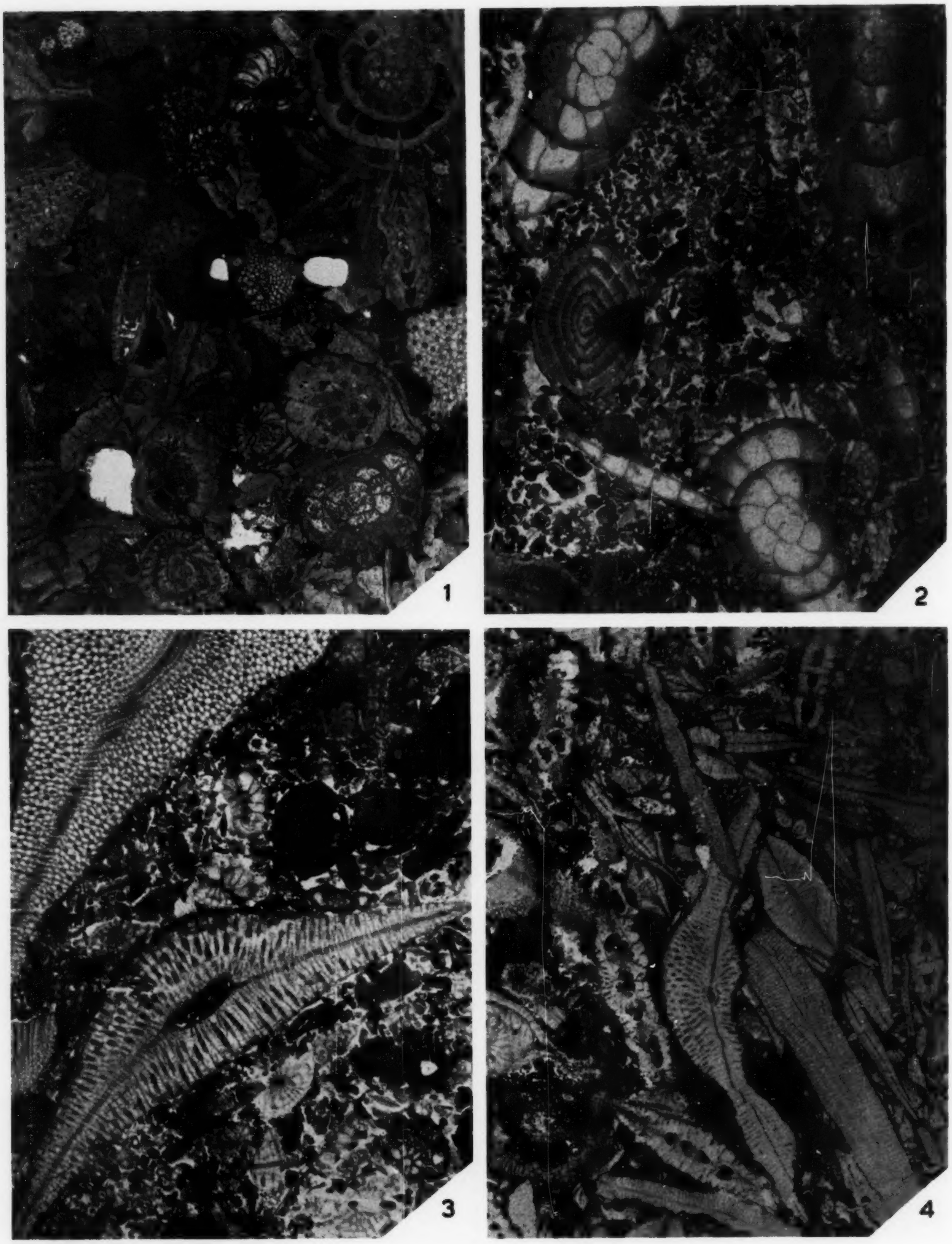
15 *Hantkenina (Cribrohantkenina) bermudezi* Thalmann
a, side view; b, edge view; Kopili stage, Maheshkhali River, Garo Hills, Assam (see text-fig. 11); Upper Eocene; × 130.

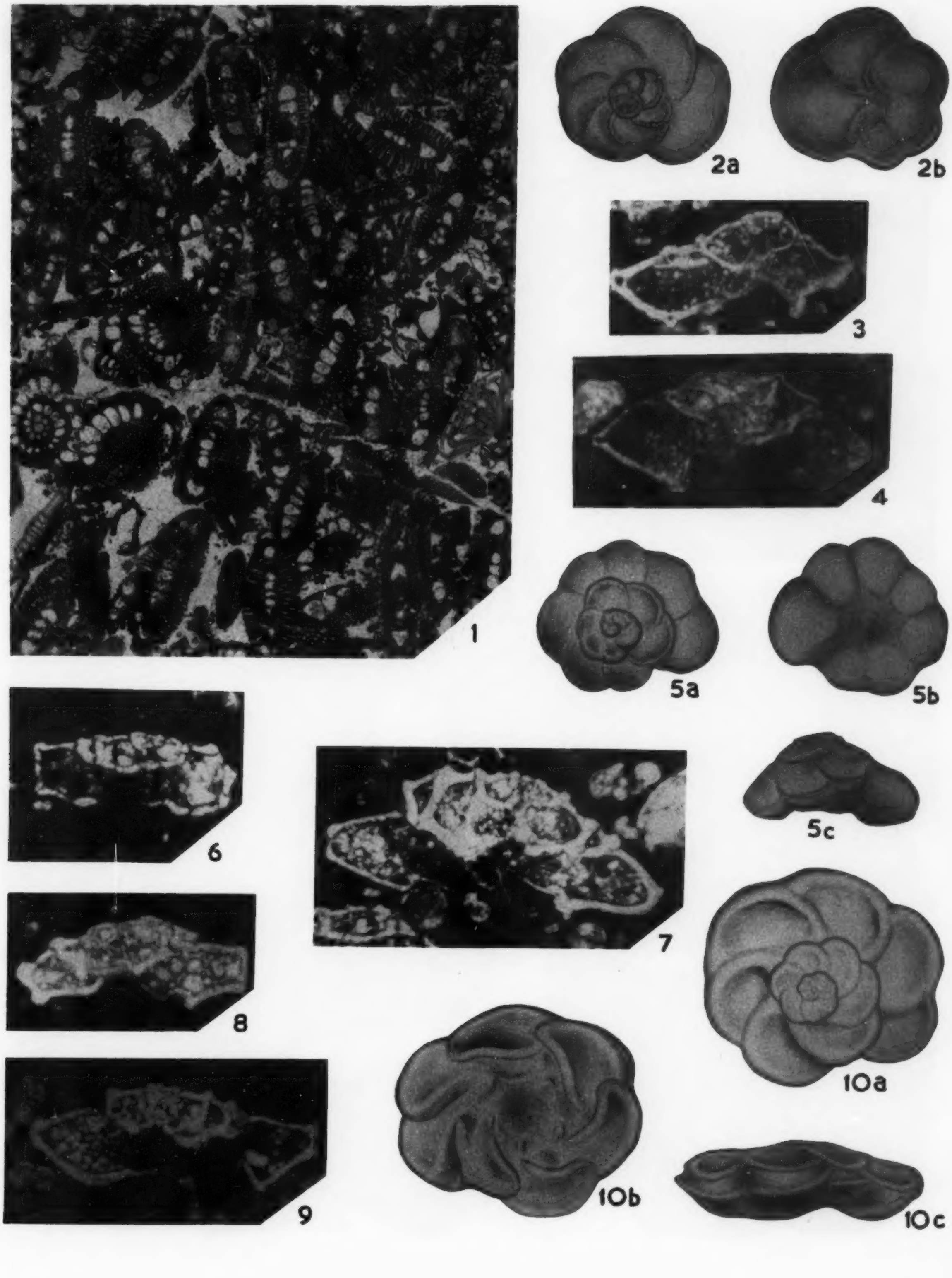

1
2
3
4

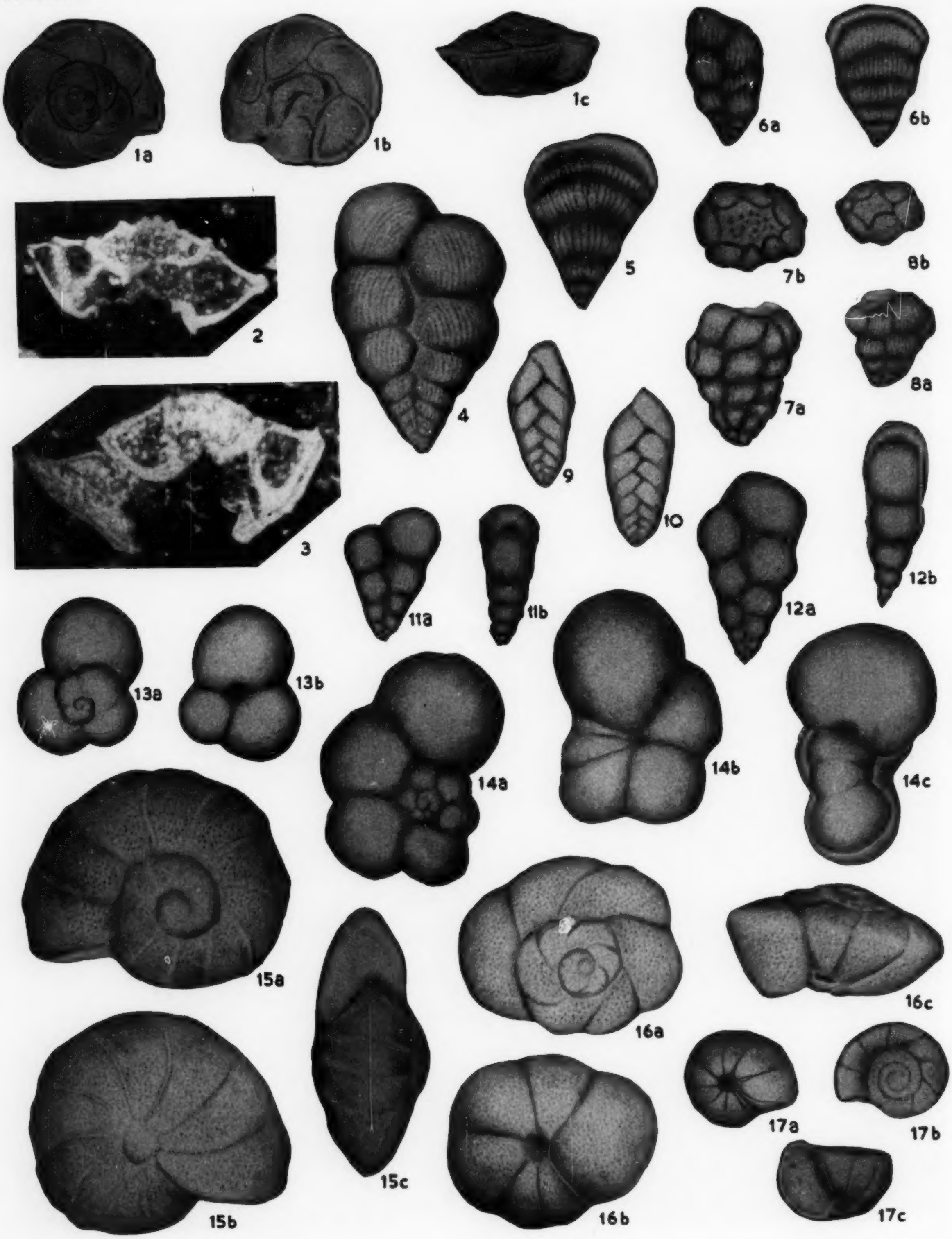

1
2
3
4

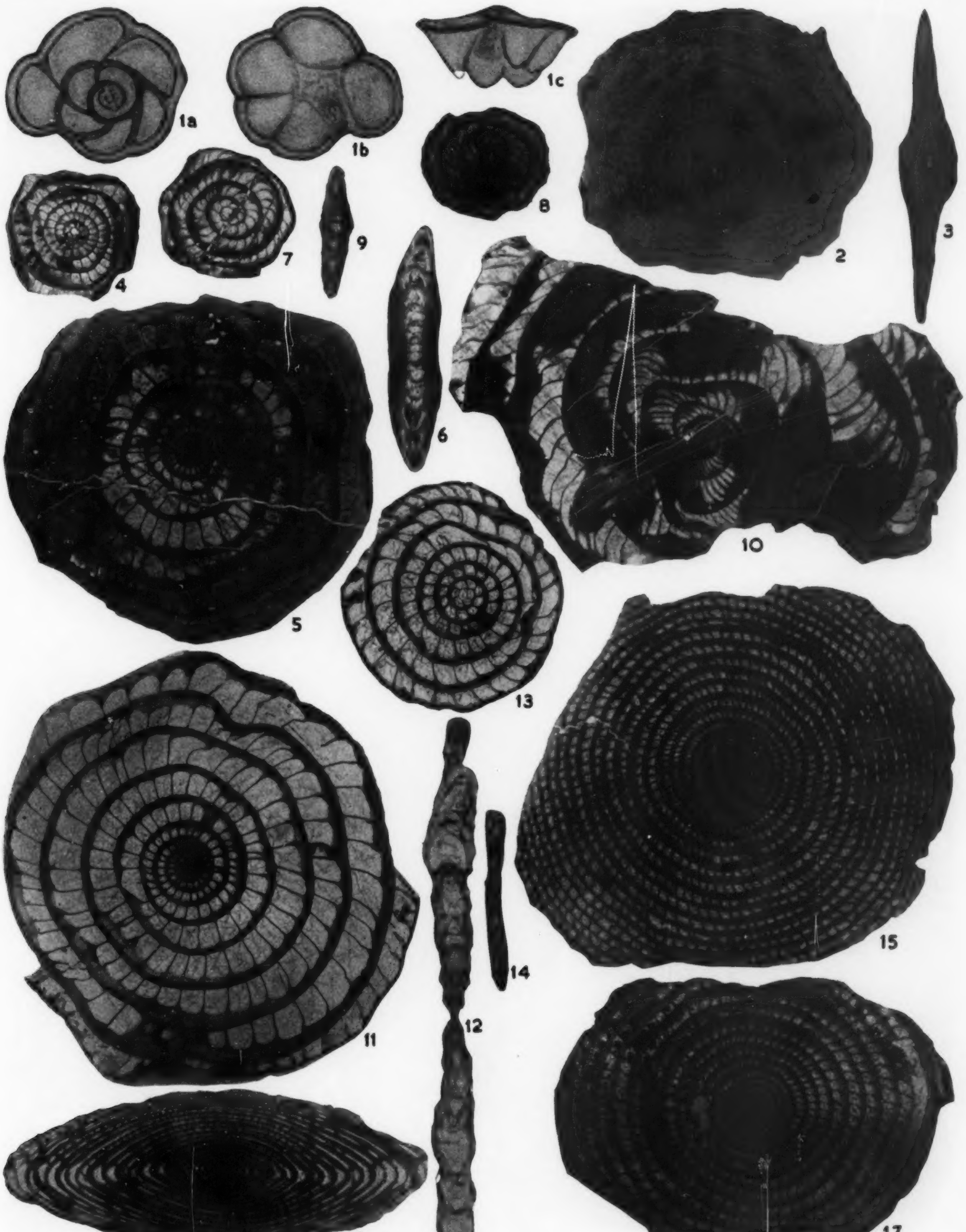

1
2
3
4


1
2
3
4

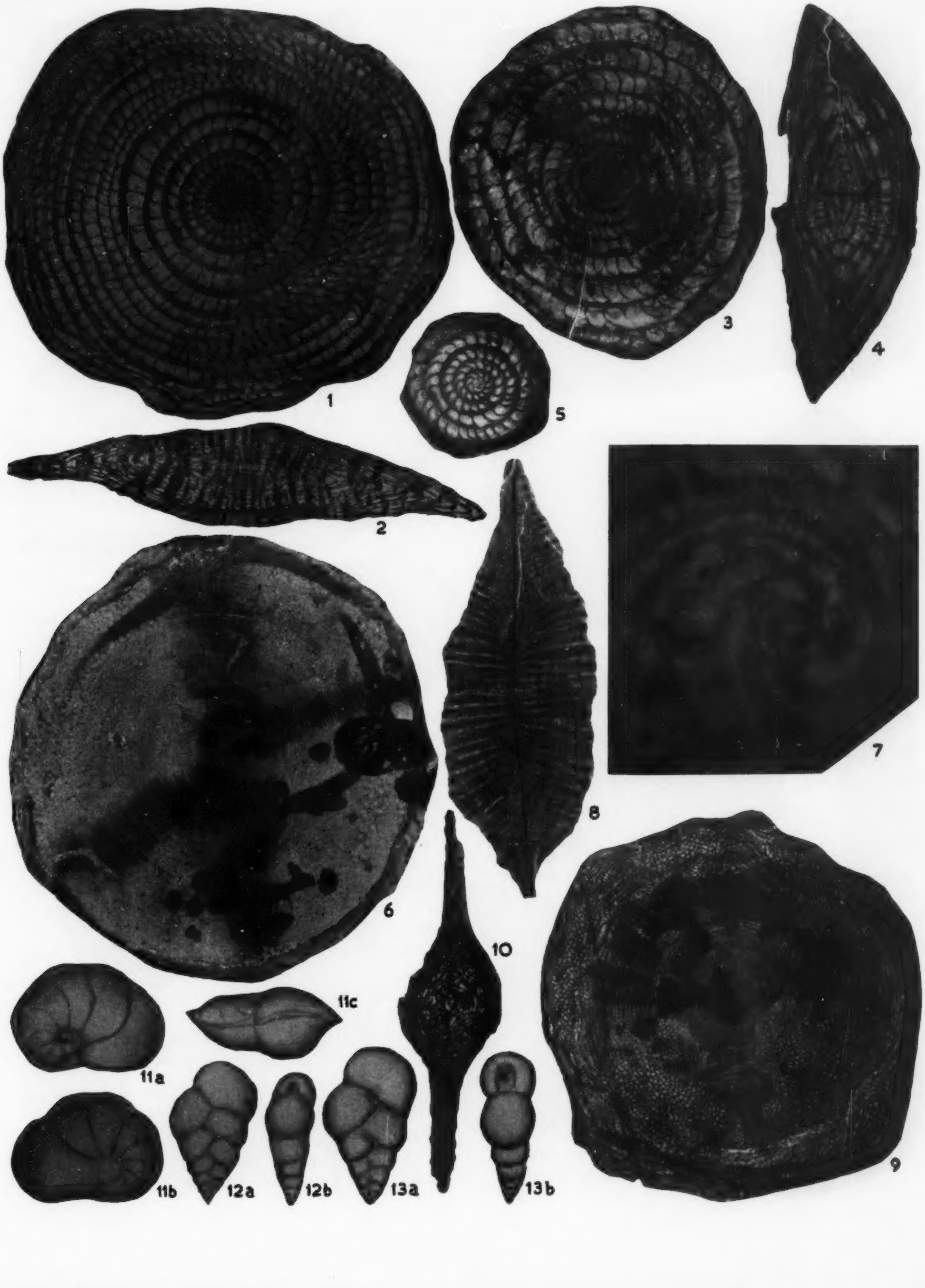

1
2
3
4

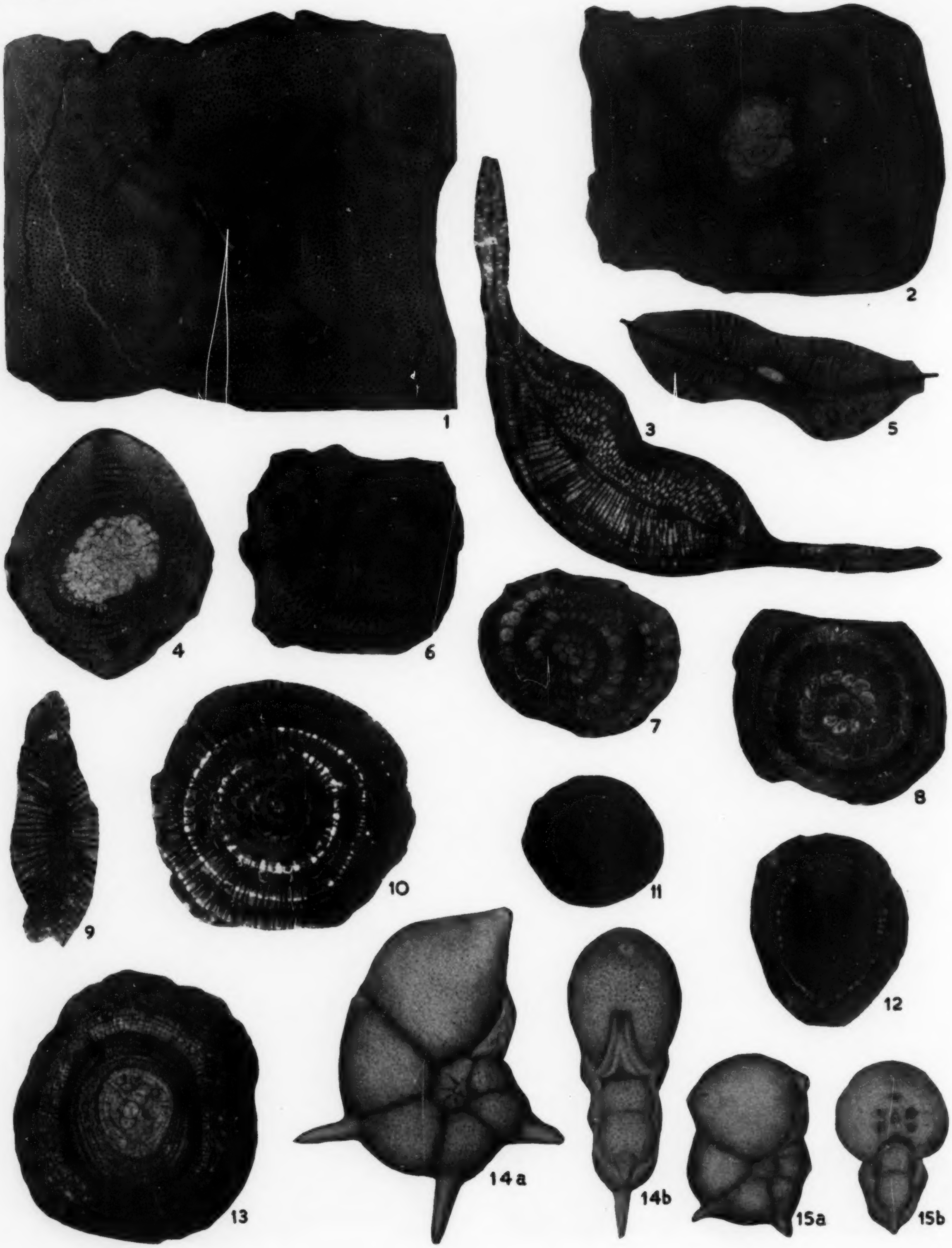

1
2a
2b
3
4
5a
5b
5c
6
7
8
9
10a
10b
10c


1a
1b
1c
6a
6b
2
3
4
5
7b
8b
7a
8a
9
10
11a
11b
12a
12b
13a
13b
14a
14b
14c
15a
15b
15c
16a
16b
16c
17a
17b
17c


1a
1b
1c
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17


1
2
3
5
4
7
6
9
8
10
11
12
13a
13b
13c


1
2
3
4
5
6
7
8
9
10
11a
11b
11c
12a
12b
13a
13b


1
2
3
5
4
6
7
8
9
10
11
12
13
14a
14b
15a
15b

ABSTRACT: Victoriella "plecte" *(Chapman) is synonymous with* "Carpenteria" conoidea *Rutten.* "Rhynchospira" abnormis *Hantken also belongs to* Victoriella. *The* Carpenteria rotaliformis *species-group indicates relationship of* Carpenteria *to* Victoriella *and* Eorupertia. *These genera, together with the new late Eocene pseudoplanispiral genus* Maslinella, *make up the Victoriellidae*; Hofkerina *is excluded. They show bilamellid wall structure, as described by Reiss. The family originated with* Eorupertia *(Eocene).* Victoriella *is rare in the late Eocene and widespread in the Oligocene to Aquitanian.*

Revision of the foraminiferal family Victoriellidae

M. F. GLAESSNER AND MARY WADE
University of Adelaide
Adelaide, South Australia

INTRODUCTION

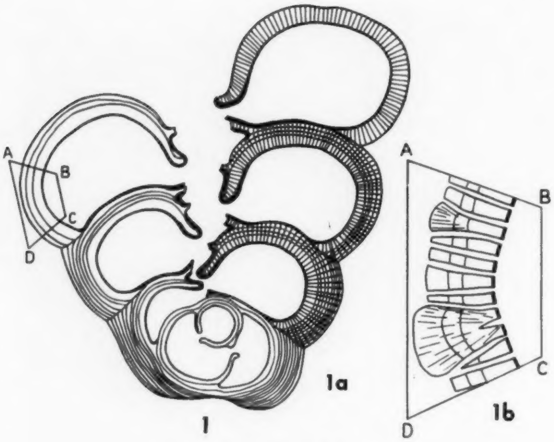
A revision of the foraminiferal family Victoriellidae appears to be timely, as doubts about the morphology and stratigraphic distribution of the type genus have led to some confusion, while at the same time new work has clarified the structure and age of the related genus *Eorupertia*. As with other revisions of foraminiferal families, this study suggests that existing generic distinctions would hardly have been made as established in the literature, had all relevant facts been known. This reflects the present unsatisfactory state of the classification of foraminifera, which is purely empirical and largely traditional instead of being based on a rational analysis of the evolution and distribution of major structural and taxonomic units. This defect cannot be remedied simply by repression or demotion to lower systematic rank of those taxonomic units whose validity now appears questionable. The danger of the traditional system is that it may lead to further multiplication of systematic units. In the present state of our knowledge, an important principle must be the practical value of newly established genera. We have introduced a new genus for a new species because of its restricted distribution in time and its strikingly different external appearance. Analysis of its internal structure shows that it is essentially a pseudoplanispiral structural variant, differing from the basic low trochospiral forms no more than the other extreme, the high-spired trochospiral forms, which so far have not been considered separate genera.

It has become obvious that external characters alone are unreliable, but it would retard the advance of knowledge of the distribution of genera and species in space and time if external characters were to be disregarded and all classification were to be based wholly on characters that cannot be seen in mass observations of material of average preservation. The correlation of internal characters, such as the layering of the walls or canal systems, with external characters, such as the arrangement of chambers, perforation, and apertures, remains a practically important objective for detailed foraminiferal studies.

The figured specimens are deposited in the collections of the Geology Department of the University of Adelaide (A.U.G.D.), or in those of the National Museum of Victoria, Melbourne (N.M.V.).

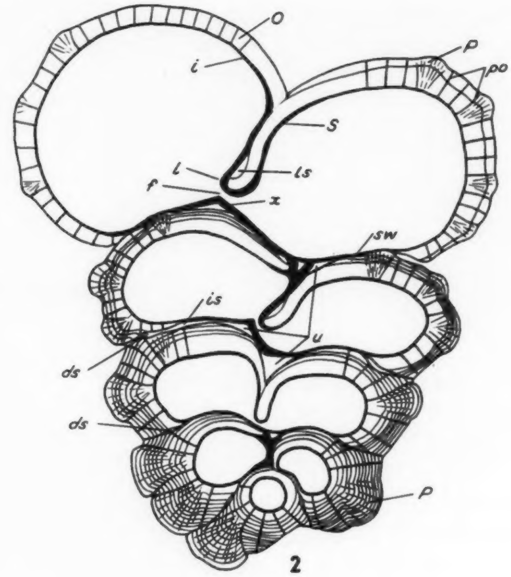
ACKNOWLEDGMENTS

Our thanks are due to Dr. C. W. Drooger, of the Geological Institute, University of Utrecht, who very kindly loaned the type slide of "*Carpenteria*" *conoidea* Rutten; to Dr. H. Hagn, of the Institute for Palaeontology and Historical Geology, University of Munich, who supplied material of "*Rhynchospira*" *abnormis* Hantken that he had collected in northern Italy; to Dr. L. Bogsch, of the Palaeontological Institute of the University of Budapest, who presented a specimen of "*Rhynchospira*" *abnormis* from Hungary; to Dr. N. H. Ludbrook, of the South Australian Department of Mines, who kindly loaned well preserved material of *Victoriella* "*plecte*" (Chapman) from the Mines Department bore Canopus no. 1; and to Miss Irene Crespin and Mr. E. D. Gill, who kindly remeasured type specimens of *Victoriella* "*plecte*" in their collections. The National Museum of Victoria, Melbourne, made the W. J. Parr Collection of foraminifera available for study. West Australian Petroleum Pty. Ltd. permitted examination of specimens from bore cores.



TEXT-FIGURE 1

Victoriella "plecte" (Chapman): a, diagrammatic vertical section, × ca. 40, showing the low-spired, globigerinid nepionic stage followed by the high-spired coil of adult growth; the radial structure of the test walls is indicated at the right side only; adult stage based on A.U.G.D. slide no. F15651, the nepionic stage on slide no. F15659; b, area ABCD enlarged to about 120 × to show layering, pillars and perforations; the longitudinal axes of the bundles of calcite fibers in the pillars diverge more sharply than those in the remainder of the walls, which remain normal to the inner and outer surfaces.



TEXT-FIGURE 2

Victoriella "plecte" (Chapman), composite tangential section (slightly diagrammatic) near axial plane, × ca. 40, cutting two adjacent chambers of a specimen with four-chambered whorls; the apical chamber is the last of the nepionic stage; *ds*, buried sutures; *is*, interlocular spaces; *f*, foramen; *i*, inner lining of chamber wall; *l*, lip; *ls*, space behind lip; *o*, outer lamina of chamber wall; *p*, pillars; *sw*, spiral wall; *u*, axial spaces; *x*, floor of chamber partially enclosing foramen.

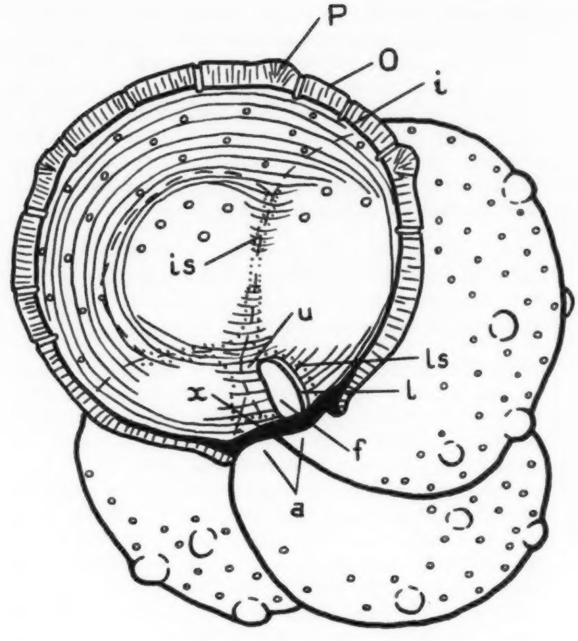
THE GENUS VICTORIELLA CHAPMAN AND CRESPIN, 1930

Redescription of Victoriella "plecte" (Chapman)

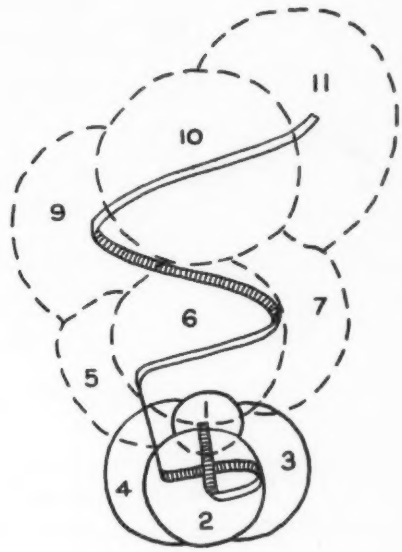
This species was first described as *Carpenteria proteiformis* Goës var. *plecte* by Chapman (1921, p. 300, pl. 51, fig. 3) from a bore in the Tertiary of Victoria, Australia. A few years later it was made the type species of the new genus *Victoriella* Chapman and Crespin (1930, p. 110, pl. 7, figs. 1–4). It was recently refigured by Crespin (1950, p. 74, pl. 10, fig. 15), who has also discussed its stratigraphic distribution and occurrence in Australia in various publications.

The material studied consisted of over 200 specimens from the southeastern part of South Australia; thirteen well preserved specimens from 500 to 510 feet in the Canopus no. 1 bore, 45 miles north of the River Murray in South Australia, near the border with New South Wales (collections of the South Australian Mines Department); over fifty specimens from the Aire Coast, southwestern Victoria (W. J. Parr Collection, National Museum of Victoria); and six specimens from Torquay, Victoria, near the bore from which the holotype was described.

Description: The test is very thick-walled, except for the last few chambers of some specimens. It is conical, with the apex of the cone truncated by a very small attachment area in all well preserved specimens. In a few, the later layers of the test wall overgrow the small flattened area; these specimens could not have been attached in adult life. The attachment area is frequently tilted to one side of the test. The chambers are inflated, approximately spherical; the later sutures are deeply depressed, but the growth of layers of shell over the early part of the test partly or wholly obscures earlier sutures. The surface is coarsely perforate, with numerous round to elliptical bosses interspersed between the perforations. The coiling of the adult chambers is trochoid, with three or (usually) four chambers in a whorl. The growth rate is most commonly uniform, but the last whorl may be rather loosely placed, causing either a sudden increase in width or a narrowing. The aperture of each chamber in turn occupies the center of the base of the cone. The apertures are arched, surrounded on three sides by a prominent lip; the floor (= axial wall) of the chamber (text-fig. 2, *x*) may also project at the base of the aperture, enclosing it on the remaining side so that it is practically tubular in some individuals. Most specimens show a shallow umbilical depression which, when overlapped by chambers, leaves small, open axial spaces radiating from the axis (*u* in text-figs. 2 and 3; pl. 2, figs. 8–9). In more loosely coiled specimens the umbilicus remains wide open, and a narrow, open axial hollow is thus formed (text-fig. 1; pl. 3, fig. 3).



3



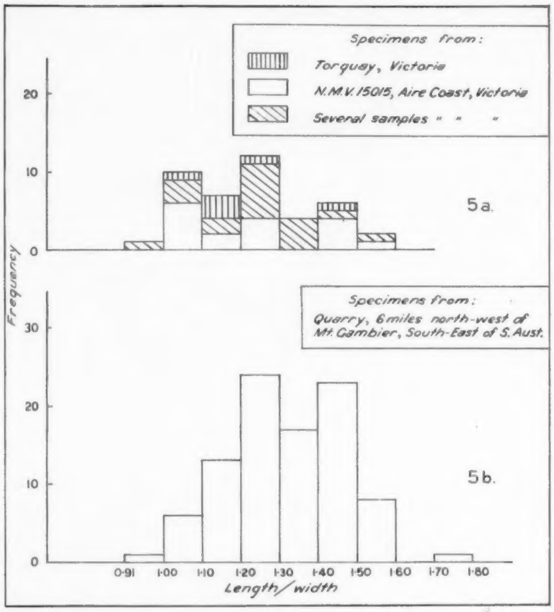
4

TEXT-FIGURES 3–4

Victoriella "*plecte*" (Chapman): 3, view into last chamber, × ca. 60, showing positions of interlocular spaces and axial spaces outlined by stippling; *a*, aperture; other lettering as in text-figure 2; 4, diagram showing a low-spired, sinistral nepionic stage succeeded after inversion by a high-spired dextral coil, × ca. 70; essential features of coiling as in slide no. F15659; the spiral runs through the centers of the chambers.

Juvenile specimens are small and *Globigerina*-like. They have irregular, scattered tubercules of shell material on the surface of the test, forerunners of adult bosses. An arched lip overhangs the aperture. Throughout growth the apertures with their distinctive lips persist as foramina; this helps in tracing the complicated coiling of the test. The initial chamber is spherical. It is connected by an oval, slightly lipped foramen with the second, inflated, chamber, which is provided with an arched, rimmed, globigerinid aperture such as occurs throughout the test. It is very rare for the initial chamber to occupy the apex of the test. The attachment area on the outside of the test usually corresponds with the dorsal sides of the second and third, or with the second, third and fourth chambers. After the third or fourth chamber, the direction of coiling is reversed. This is clearly shown by the position of the foramina, the initial chamber, and the thickening of the outer wall of the first whorl. A sinistral spiral becomes dextral, and vice versa (text-fig. 4). In ten thin sections in which the fragile walls of the early chambers were preserved, reversal of coiling occurred after two chambers in one specimen, after three chambers in two, and after four chambers in seven specimens; in two other sections it probably occurred after four chambers. After reversal, regular trochospiral coiling is maintained. Although alternating chamber arrangement was described in the original generic description of *Victoriella* and has often been mentioned in the literature, it does not occur. The curved early walls of the first whorl contrast with the flattened attachment area, which lacks some of the later-formed shell layers. This suggests that individuals did not become attached until several chambers had been formed, and attachment probably led to reversal of coiling, as it does in some specimens of *Carpenteria.*

In thin section, the primary wall of each chamber, including the last, is seen to consist of two layers, a thick outer lamina and an inner lining which is thin where the walls are perforate but may be relatively thick elsewhere (pl. 2, fig. 9). The two layers of calcite crystals are in optical continuity with each other. The inner layer frequently appears darker in transmitted light, and the two layers are normally separated by a thin, dark line. Near the aperture the inner lining thickens, and both layers are turned outward to form the lip (text-figs. 1–2; pl. 2, figs. 8–9; pl. 3, fig. 3). In well preserved specimens, they can be recognized in reflected light by the contrast between the whitish internal surface of the chambers, particularly the



TEXT-FIGURE 5

Graphs showing the frequencies of different ratios of length to width in *Victoriella "plecte"*: a, from southwestern Victoria; b, from Tartwaup Quarry, 6 miles northwest of Mt. Gambier, southeastern South Australia.

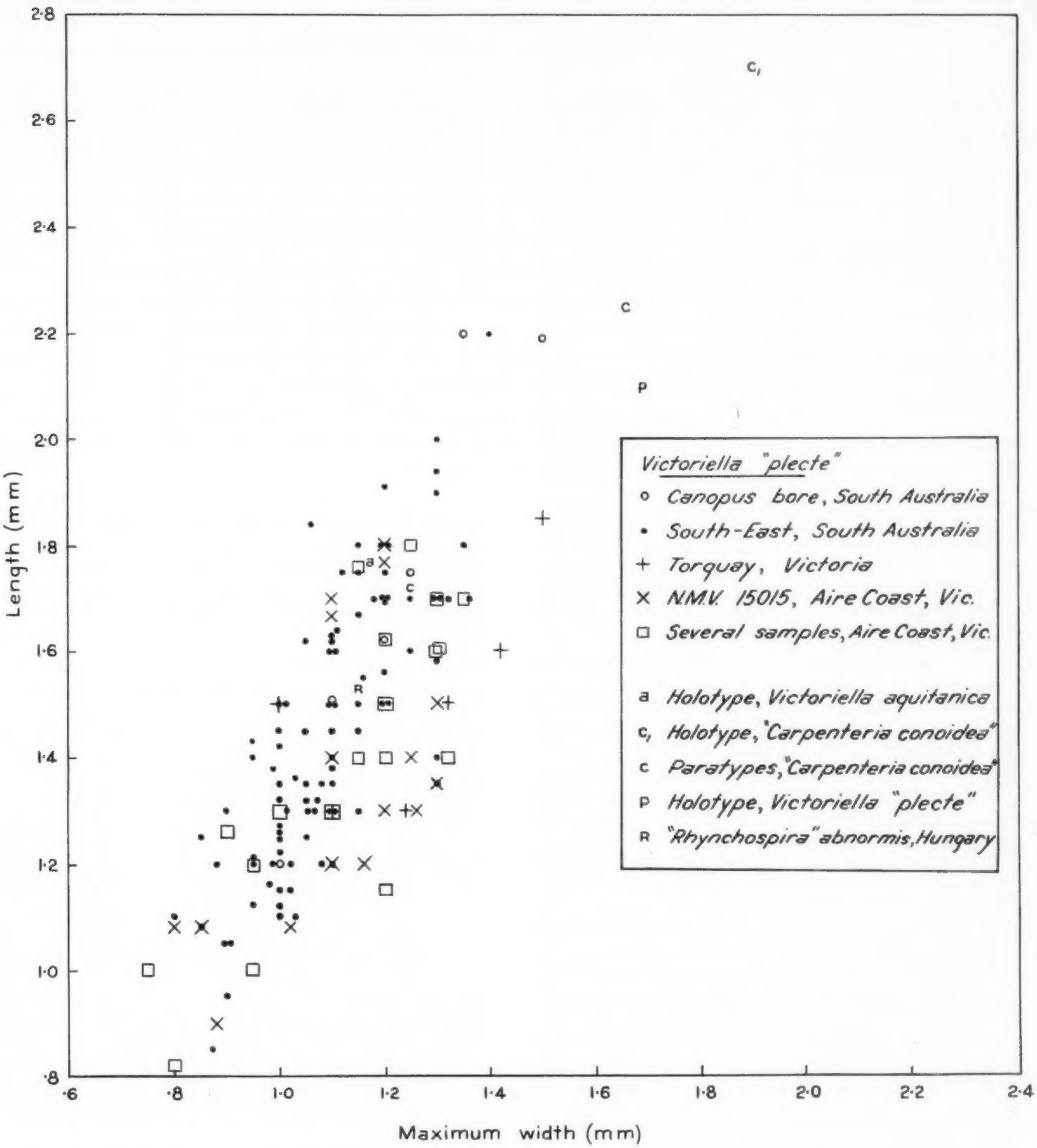
thicker, whitish lips of the aperture and foramina, and the grayish external walls. With the addition of each new chamber during growth, its outer lamina extends over the whole test. The walls are thus thickened toward the apex by the deposition of a layered outer ("secondary") portion. The new material is added in optical continuity with the surface that it covers. The layers can be clearly seen, but they cannot be traced from chamber to chamber because of the resulting sharp optical discontinuity between the walls of adjoining chambers. This reflects the position of the sutures through outer walls several times thicker than the primary chamber walls or the ventral spiral wall. The inner lining encloses the whole chamber lumen. It is the only layer added to the center of the septal face, so that the septa consist of three layers, the inner lining and the outer lamina of the preceding chamber, and the inner lining of the succeeding chamber (pl. 2, fig. 9). Spaces are left in the walls between the approximately globular chambers. Some of these spaces (*u* in text-fig. 2) are equivalent to the axial hollow in text-figure 1; some *(ds)* are depressed sutures buried by later layers of shell material; some (interlocular spaces, *is*) are spaces which are often, but not always, found along sutures crossing the ventral face of the test, as in text-figure 3. Lastly, spaces *(ls)* are trapped above the lip, between it and the second and third layers of the septum. These are also seen in plate 2, figure 8. They connect with the umbilical spaces, at least in some specimens.

The pores, which are evenly distributed on the inner surface of the chamber walls, are often displaced by the growth of pillars between them as they traverse the outer layer of the test. As more layers are added to the walls, the pillars increase in size until the bosses marking their outer ends measure up to 0.15 mm. If, as often happens, the last one to three chambers have disproportionately thin walls, their outer portion may not be thick enough for pillars to develop properly or at all.

In the better-preserved empty tests, a thin film of organic material lines the chambers, fitting closely to the walls but contracting from them during sectioning. The wall structure is calcareous radiate.

Remarks: The two-layered primary chamber walls are typical of the "superfamily Bilamellidea" of Reiss (1957*a*, *b*), and are distinct from the single-layered primary chamber walls of the typical Rotaliidea. According to Reiss, the "Bilamellidea" possess a "septal-peristomal" canal system, developed between the layers of individual primary chamber walls. The origin of this structure differs from the canal system in the Rotaliidea. Reiss (1957*b*, text-fig. 1) shows the septal-peristomal canals between the inner lining and outer lamina running across the base of the apertural face and in the lip which overhangs the aperture; occasional canals are developed elsewhere in the area seen in sections as a "dark line" between the inner linings and outer laminae. The septal-peristomal canal system as described by Reiss runs in the same area as the "basal mantle" described by Anisgard (1957) in "*Eorupertia*" *bermudezi*, but it is restricted in width, whereas the "basal mantle" was described as if it were a space completely separating the two layers.

Reiss states that the septal-peristomal canal system is present in *Eorupertia* (1957*a*, pp. 4, 5; pl. A, figs. 1, 3; pl. B, figs. 4–5), but we have not been able to observe it in our moderately well preserved material. A dark line between the septal layers is present in the Victoriellidae, as various authors have shown. In *Victoriella* the dark line widens inside the lip, but no open spaces have been observed in it. At magnifications of more than about 300×, it can be seen as a zone from which crystallization appears to have spread radially inward and outward. Its dark-speckled color may be due to micro-inclusions, as is the case in *Discorbis propinqua* (Terquem), which has septal-peristomal canals. In *Victoriella*, however, inclusions could not be resolved at a magnification of 430× with an oil-immersion lens and binocular eyepieces, or at 650× with a monocular eyepiece. The dark speckling may be an optical effect due to the arrangement of fibres of calcite. Regarding "*Eorupertia*" *bermudezi*, Anisgard (1957) assumed the simultaneous formation of the inner lining and the outer lamina. Reiss (1957*b*, p. 128) independently reached the same conclusion for the "Bilamellidea" in general, although Hagn (1955, p. 57) inferred that in *Eorupertia* the inner lining (his "primary lamella") was formed before the outer lamina ("central lamella"). Hagn stated that the

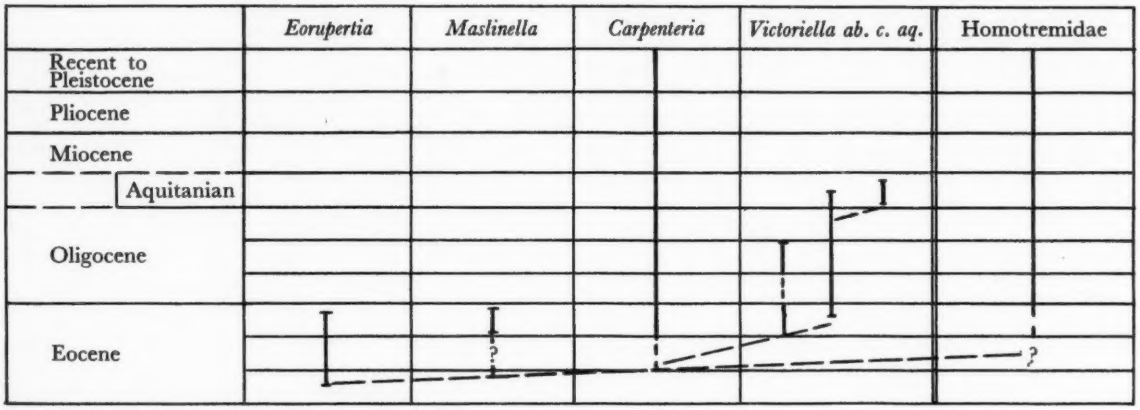


TEXT-FIGURE 6

Scatter diagram of length (in mm.) plotted against width (in mm.) for *Victoriella "plecte"* (Chapman) compared with *Victoriella conoidea* (Rutten), *Victoriella aquitanica* Debourle and Delmas, and *Victoriella abnormis* (Hantken). The dimensions of the holotype of *Victoriella "plecte"* are altered from those indicated by Chapman to correspond with new measurements supplied by E. D. Gill, of the National Museum of Victoria, where the specimen is deposited.

TABLE 1

STRATIGRAPHIC DISTRIBUTION AND RELATIONS OF THE VICTORIELLIDAE



Species of *Victoriella:* *ab*, *V. abnormis;* *c*, *V. conoidea;* *aq*, *V. aquitanica.*

"secondary lamella" (the inner lining of the chamber succeeding a septum) is sometimes well developed but is more often incomplete or absent in *Eorupertia cristata.* It is always present in *Victoriella* "*plecte*," though frequently very thin over the center of the previous apertural face.

In the Victoriellidae, spaces are left in the walls between the inflated chambers. In some species they may interconnect, and have been described as a canal system by several authors (Yabe and Hanzawa, 1922; Hagn, 1955; Anisgard, 1956). In other species they are not connected or may even not be present at all (Anisgard, 1957). As the term is used in this paper, the "axial spaces" enclosed between the layers of the septa (the outer lamina of the preceding chamber and the inner lining of the succeeding chamber) and the spiral wall of the preceding whorl are equivalent to the "secondary chamberlets" that Hagn described and figured (1955, p. 57, pl. 4, fig. 7; pl. 6, fig. 3) enclosed between the "central lamella" and the "secondary lamella" of the septa and the spiral wall. Debourle and Delmas (1955, p. 48) used the phrase "espaces interloculaires" for all the spaces enclosed between chambers, but the term "interlocular spaces" has been used in this paper in a slightly restricted sense for the connections between the axial hollow (or axial spaces) and the external surface. "Lumen" was used by Reiss (1957*b*, pp. 4, 5). Reiss does not accept the interlocular spaces as canals, stating (p. 5): "the lumen between consecutive coils, as well as that between consecutive chambers, as seen in sections, do not represent canals (and neither are they sectioned "secondary chamberlets"), but are conditioned by chamber form and arrangement and by the mode of growth." Although the interlocular spaces of the Victoriellidae occupy much the same relative position as the septal branches of the rotaliid canal system, they are not part of any organized system. There is no trace of a spiral canal connecting them. They represent a morphological convergence between the "Bilamellidea" and the Rotaliidea. The term "interlocular spaces" is preferable, as it avoids confusion with either the canal systems or the chamber lumina.

Variability: The length and the maximum width of the better-preserved adult specimens were measured, and the ratio of length to width was plotted against the frequency (text-fig. 5a–b) of the Victorian and South Australian specimens. Their positions on a scatter diagram are shown in text-figure 6. The graphs bear out the visual impression that the coiling of the last whorl tends to be wider and flatter in the Victorian specimens. A comparison (text-fig. 5a) between the richest sample from the Aire Coast and the remainder of the specimens from that locality (several samples) indicates that the coiling is not necessarily uniform in one district. The few specimens from Torquay show agreement with the general Victorian picture. The two thin sections of Torquay specimens were measured at the penultimate whorl as well as at the last, and show a rapid increase in width, one section more than the other. The Victorian variants have also been found more rarely in the South Australian material, and the slight difference may be ecological, as the species is much more numerous in South Australia, where it is more uniform.

The measurements of three fairly well centered vertical sections of *Victoriella conoidea* are plotted in text-figure 6 together with those of *Victoriella* "*plecte*," of the holotype of *Victoriella aquitanica* Debourle and Delmas, and of a specimen of "*Rhynchospira*" *abnormis* Hantken from the Middle Oligocene of Hungary. The graph shows a single field of variation.

Synonymy of species of Victoriella

1) "*Carpenteria*" *conoidea* Rutten:

Referring to *Victoriella* "*plecte*," Glaessner (1951, p. 276) stated: "The only record in the literature referring to this or a similar species is *Carpenteria conoidea* Rutten from the Aquitanian limestones of northern New Guinea." *Victoriella* "*plecte*" has been compared with the type slide of *Carpenteria conoidea* Rutten (1914), no. 922, slide D.7279, in the collections of the Geological Institute of the University of Utrecht. The slide is exceedingly rich in *Victoriella*, and the four sections that were figured by Rutten (1914, pl. 7, figs. 6–9) are easily recognizable. The original of Rutten's figure 9 is here selected as the lectotype. The originals of his figures 7 to 9 and many other sections are conspecific with *Victoriella* "*plecte*" (see pl. 2, figs. 1–5). *Carpenteria proteiformis* Goës var. *plecte* Chapman, 1921, is thus a junior synonym of *Carpenteria conoidea* Rutten, 1914, and the valid name of the type species of *Victoriella* is *Victoriella conoidea* (Rutten).

The individual shown in Rutten's figure 6, which he specifically likened to a section of *Carpenteria balaniformis*, is not a *Victoriella* but is probably a *Carpenteria*. It has much thinner walls than *Victoriella conoidea*, lacks pillars in them, and has two layers of equal thickness, separated by a thin dark line, in the walls of the last chamber.

2) *Rhynchospira abnormis* Hantken:

A well preserved specimen of *Rhynchospira abnormis* Hantken (1875), from the Middle Oligocene of Demjén, near Eger, Hungary (at 73.3 meters in bore no. 9), was kindly presented by Dr. L. Bogsch (University of Budapest). Comparison of this fossil and of Hantken's type figure and description with the description of the type species of *Rhynchospira*, *Rhynchospira indica* Ehrenberg (Recent, Malacca Strait, *fide* Ellis and Messina), shows that "*Rhynchospira*" *abnormis* is not a *Rhynchospira* but a *Victoriella*. Specimens from the Upper Eocene of northern Italy were referred to *Victoriella abnormis* (Hantken) by Hagn (1956). One of two specimens made available by Dr. Hagn was sectioned and proved to have the third and fourth chambers at the apex, above the first and second. In its finer structures it agrees closely with *Victoriella conoidea*. The three European specimens have smaller bosses than almost all the Australian specimens. The well preserved Hungarian specimen apparently lacked an attachment area; of the less satisfactory Italian specimens, the one sectioned appeared to lack an attachment area, the other appeared to have a small one. They have three or four chambers per whorl. Until it becomes possible to examine the holotype and larger populations of the European form, the smaller size or absence of the attachment area, and the smaller size of the pillars, must suffice for its specific differentiation from *Victoriella conoidea*, although a few Australian specimens show equally small pillars.

3) *Victoriella aquitanica* Debourle and Delmas:

This form was described from the Oligocene (probably Aquitanian) of Mimizan, Landes, France, by Debourle and Delmas (1955). They differentiated *Victoriella aquitanica* from *Victoriella* "*plecte*" on the ground that it was regularly trochospiral from the earliest to the latest stage. The lack of the nepionic stage that characterizes *Victoriella conoidea* (including *Victoriella* "*plecte*") and *Victoriella abnormis* would certainly isolate *Victoriella aquitanica* from these two species, but the other features that Debourle and Delmas considered distinguishing are found in numerous South Australian specimens. These features include a more conical shape and more regular coiling, resulting in less depressed sutures. Unfortunately, the figured vertical section is tangential, and it is impossible to tell whether or not it passed through the initial chamber. Its apical flattening could be due either to breaking of the specimen or to non-deposition of shell layers on an attachment area. Since the species has been described as having a free test, well preserved specimens should lack the small attachment area seen in well preserved *Victoriella conoidea*. Their figures show that there is no obvious external difference between *Victoriella aquitanica* and *Victoriella conoidea*. The generic characters are well displayed, but the character of the early coiling upon which the specific identity appears to depend is not illustrated. Pending further sectioning to clarify this character, it seems probable that *Victoriella aquitanica* Debourle and Delmas will prove to be a synonym of *Victoriella conoidea* (Rutten).

4) Records from Saipan:

Cole (1957) described a species from the Upper Eocene of Saipan as *Eorupertia plecte* (Chapman), indicating (p. 328) that the same species had been identified earlier by Hanzawa (1957) as *Carpenteria proteiformis* Goës. The specimens figured by Cole (pl. 102, figs. 4–6), as well as those figured by Hanzawa from the Eocene (pl. 36, figs. 11, 13; pl. 38, fig. 6), do not represent Chapman's species, which has the strong pillars that form a distinctive character of the genus *Victoriella*, nor is their shape conical. There is nothing to exclude them from the genus *Carpenteria*. Cole's specimens resemble the new species *Carpenteria hamiltonensis* Glaessner and Wade (see below). Cole's opinions that *Eorupertia boninensis* and "*Eorupertia plecte*" may be found to represent one species, and that the differences between *Victoriella* and *Eorupertia* are specific rather than generic, have not been confirmed by the present investigation.

In 1953, Cole (in Cole and Bridge, 1953) described a section from the Tagpochau limestone of Saipan (considered to be Aquitanian to Burdigalian) as *Victoriella plecte*. This specimen was placed by Hanzawa (1957, p. 70) in *Sporadotrema cylindrica* (Carter), but this and other records of the latter species published by Hanzawa were assigned by Cole (1957, p. 338) to the Australian Miocene species described by Howchin (1889) as *Pulvinulina semiornata*. This species is currently known as *Hofkerina semiornata*, but was placed by Cole in *Eorupertia*.

The results of our re-examination of the holotype, paratypes, and other Australian material of *Hofkerina semiornata* show clearly that this form is not identical with or even closely related to *Eorupertia*. Cole's specimens (1957, pl. 103, figs. 11–13 and 15–16) differ very considerably from Howchin's species in the structure of the walls and in the chamber arrangement, with the exception of the section figured on pl. 103, fig. 14, which, judging from the photograph, could represent a *Hofkerina*. The other forms figured by Cole, and those assigned to *Sporadotrema cylindricum* (Carter) by Hanzawa, are at present best left in this genus, at least until it can be revised in detail.

RELATIONSHIPS TO OTHER GENERA

Carpenteria Gray

In the absence of specimens or of a modern description of the tvpe species, *Carpenteria balaniformis* Gray, we are forced to rely on the description and figures given by Carpenter (1862). He showed that the early stage of the species is a spiral of inflated chambers, and concluded that its affinities lie near the globigerinids. His figures (pl. 21, figs. 5, 11) seem to represent a bilamellid wall. Additional spaces are entrapped in the walls in a sutural position (pl. 21, figs. 3–4). As figured, the canal system provides no evidence of relationship; it could be explained either as a "bilamellid" system of septal-peristomal canals or, with more difficulty, as a rotaliid canal system. Hofker (1930, pls. 50–52, several figures) figured and described inflated early stages in *Carpenteria utricularis* (Carter), *Carpenteria monticularis* Carter, and *Carpenteria raphidodendron* Möbius. He denied the presence of a canal system (p. 126), but he did not have the type species in his material.

The Australian species referred to *Carpenteria* have bilamellid walls and lack the rotaliid canal system. The most common form is *Carpenteria rotaliformis* Chapman and Crespin. Following the original description (Chapman and Crespin, 1930, p. 98, pl. 5, figs. 7–8), the adult stage was well figured by Chapman, Parr and Collins (1934, pp. 572–573, pl. 11, fig. 44a–c). This figure shows the typical shape of a megalospheric specimen.

The megalospheric generation (pl. 2, fig. 6) has a free, thick-walled, *Globigerina*-like nepionic stage which does not become attached until four or five chambers have been formed. Like the young stage of *Victoriella*, it has a thick, arched lip around three sides of the aperture. Layers of shelly material are added to the outer wall during growth. The attachment area is shared by the outer layers of usually three of the first four chambers and of several later chambers. As a general rule, attachment is on the side away from the first chamber, and the later growth, directed away from the substratum, is in the opposite direction from the early growth; this is seen in neanic specimens and can be shown by careful sectioning of adult specimens, as the early chambers do not lie in one plane. Sometimes the direction of coiling is also reversed. One or two whorls, of four or five inflated chambers each, often stand clear of the substratum, but the size of the attachment area is highly variable; its average size is smaller in the older (Upper Eocene) members of the species. The size of the megalosphere is variable, but at present there is no evidence for two megalospheric generations.

The microspheric generation is rather rare. Its coiling is trochospiral, and it appears, from a study of two very young specimens, to be adherent throughout life. Attachment is on the dorsal side of most or all of its chambers. So far as known, the adult is conical, and its chambers are much less inflated than those of the megalospheric generation. The umbilical edges tend to be peaked, covering the umbilicus. The aperture is on the ventral side, basal in the young stage and basal to umbilical in the adult.

In both megalospheric and microspheric generations the perforations are coarse, and penetrate the inner and outer laminae of the chamber walls and the secondary layers added during growth. At magnifications of more than about 400×, very fine partitions can be seen to cross the perforations; they correspond in position with the borders of the laminae. Similar partitions have been observed in *Carpenteria proteiformis* Goës from the Miocene (Tortonian) of Kostej, Romania. Hickson (1911) described incomplete calcareous partitions in *Sporadotrema mesentericum* (Carter). In the nepionic stage of the megalospheric generation, the coarse perforations open to the surface at the top of small pustules. After attachment the pustules are fused, and the perforations open in indentations in a rather rough surface. Galloway and Heminway (1941, pl. 27, fig. 2a–b) figured this character very clearly when they described *Carpenteria bulloides*, a species that is close to *Carpenteria rotaliformis* although specifically distinct, which they hesitantly assigned to *Carpenteria*. In the microspheric generation the perforations open on a rather smooth surface in the young stage, but the adults have a surface like the megalospheric generation. Another member of this species-group is *Carpenteria hamiltonensis* Glaessner and Wade, n. sp. It is apparently related to *Carpenteria rotaliformis*, with which it occurs in the Upper Eocene. It also bears a great resemblance to *Victoriella conoidea* (Rutten) and to "*Eorupertia*" *bermudezi* Anisgard.

Carpenteria hamiltonensis Glaessner and Wade, **new species**

Plate 1, figures 8–10; plate 3, figures 1–2

Material: Twenty-four specimens were available in the Parr Collection, slides N.M.V. 14905 (Hamilton Creek), 15003 and 15004 (road cutting on Great Ocean Road near Hamilton Creek), east of the Aire River, south-western Victoria. It is rare at Maslin Bay, 20 miles south of Adelaide, South Australia.

Description: Test conical, with a small attachment area at or near the apex of the cone. It usually consists of three inflated chambers in each whorl, and tapers regularly from the last whorl to the apex, but sometimes the

apex is obtuse, with more than three chambers in the first post-nepionic whorl (pl. 3, fig. 1), or the coiling is less regular. There may be up to five chambers in the last whorl; in these specimens the width of the test increases rapidly, although the length is necessarily less for a similar number of chambers than the length of tests built entirely on the three-chambered plan. The aperture is arched and umbilical. It is surrounded on three sides by an out-turned lip, and may be enclosed on the remaining side by the floor of the chamber. The walls are very coarsely perforate. The perforations may open at the surface on small pustules or, more commonly, the pustules are fused so that the perforations open to the surface in small depressions, and the surface of well preserved specimens may be rather rough. The perforations are evenly spaced over the walls, which do not have pillars.

Thin sections show that the early part of the test is a small spire of about four subspherical chambers. After this the axis of coiling is twisted, and the adult trochospiral coiling is established. Usually, as in plate 3, figure 2, there are three chambers per whorl, but sometimes (pl. 3, fig. 1) the earliest post-nepionic chambers form part of a whorl, which, if complete, would have numerous chambers. Coiling with three chambers per whorl follows abruptly. As far as can be judged from adult specimens, attachment took place after the nepionic stage.

The primary wall of each chamber consists of a thick outer lamina and a thin inner lining. Both are penetrated by coarse pores except near the aperture. As each chamber is added, material of the outer lamina is laid down over the whole surface of the test in optical continuity with the underlying material; some layers can be traced from chamber to chamber (pl. 3, fig. 1), if there is not too great a disparity in the alignment of crystals in the walls. The inner lining often does not cover the septal face completely, but similar material forms a floor on the axial side of the chamber and roofs in interlocular spaces extending from the axial area to the outer surface. Thus the septal face in thin section may appear two-layered or partly three-layered or three-layered with an interlocular space between the two laminae of the preceding chamber and the inner lining of the succeeding chamber. The wall-structure is calcareous radiate.

A thin film of organic material lines the inside of the test. It fits closely to the inner wall and cannot be distinguished until it contracts away from the wall during sectioning (pl. 3, fig. 2).

Dimensions of holotype and paratypes (N.M.V. Collection): Holotype (P17685): Length 1.3 mm.; maximum width 0.92 mm. Paratype (P17684): Length 1.36 mm.; maximum width 0.80 mm. Paratype (P17686): Length 1.5 mm.; maximum width 1.16 mm.

Age: Carpenteria hamiltonensis is found in the Upper Eocene with *Hantkenina alabamensis compressa* at Hamilton Creek, Victoria, and at Maslin Bay, South Australia.

Remarks: Carpenteria hamiltonensis differs from *Carpenteria rotaliformis* in its narrower and more elongate-conical shape. Some specimens show a close relationship to *Carpenteria rotaliformis* (pl. 1, fig. 9; pl. 3, fig. 1), the nepionic phase being followed by several chambers forming part of a whorl, before adult coiling with three chambers per whorl is established. Since some specimens with a narrow, tapering early portion and more than three chambers in the last whorl also seem to belong to *Carpenteria hamiltonensis*, it follows that there must be a few specimens in any population which are indistinguishable from *Carpenteria rotaliformis*. As the ratio of individuals of *Carpenteria hamiltonensis* in proportion to *Carpenteria rotaliformis* varies from place to place, and as *Carpenteria rotaliformis* continues to be numerous in samples from continuous rock sequences after *Carpenteria hamiltonensis* is no longer found, it seems best to distinguish between the two forms specifically.

Most of the specimens greatly resemble *Victoriella conoidea* (Rutten) in shape. They are distinguished from it by the lack of pillars, the less regular coiling, and the common occurrence of three-chambered whorls.

Anisgard (1957) has described as *Eorupertia bermudezi* an elongate conical to almost cylindrical form that lacks pillars in its walls and has its apex truncated by a small attachment area. He states that it does not have an "early rotaloid coil" like *Eorupertia boninensis* (Yabe and Hanzawa), the type species of *Eorupertia*, and he illustrates this point in his plate 1, figure 8. It seems possible that the early stage is globigerinoid like those of the megalospheric forms of *Carpenteria rotaliformis*, *Carpenteria hamiltonensis*, *Carpenteria bulloiaes*, and *Victoriella*. Although, according to Anisgard, "*Eorupertia*" *bermudezi* is set apart by its imperforate inner lining, it is tentatively placed in *Carpenteria*. Its smooth surface and imperforate lining distinguish it from *Carpenteria hamiltonensis*, and these features, together with the lack of pillars in the walls, differentiate it from *Victoriella*.

Eorupertia Yabe and Hanzawa
Plate 1, figure 16; plate 2, figure 11

Chapman and Crespin (1930) associated *Eorupertia* Yabe and Hanzawa with *Victoriella* in the family Victoriellidae. Hagn (1955), after describing *Eorupertia cristata* (Gümbel) in detail and reviewing other species of the genus, accepted this assignment. Nagappa (1956) figured specimens which he described as *Eorupertia boninensis* (Yabe and Hanzawa), the type species of *Eorupertia*, clearly showing the great similarity of the early stage to that of *Eorupertia cristata*. It is also very similar to microspheric specimens of *Carpenteria rotaliformis*, but the megalospheric form in the *Carpenteria rotaliformis* species-group is closer to *Victoriella*. Reiss (1957*a*) showed that *Gyroidinella magna* Le Calvez, 1949, is a species of *Eorupertia*, with which *Eorupertia incrassata* var. *laevis* Grimsdale, 1952, is identical.

Contrasting with the slit-like aperture of *Eorupertia*, *Victoriella* has a prominently lipped aperture from the nepionic stage throughout growth. There is an abrupt change in the type and direction of coiling between the juvenile and adult in *Victoriella*, whereas the change is gradual in *Eorupertia*. There is never any tendency in *Victoriella* for the chambers of later whorls to embrace earlier whorls. Its adult whorls usually overlap ventrally sufficiently to reduce the umbilicus to dissociated remnants, but in *Eorupertia* an "axial hollow" (Yabe and Hanzawa), "umbilicus" (Hagn), "hollow, central axis," "tube" and "lumen" (Anisgard), "lumen" (Reiss), or "narrow, hollow centre" (Nagappa), persists. Both genera become attached early in life, but may be free in the adult, although the attachment area is usually smaller in *Victoriella*.

Maslinella Glaessner and Wade, **new genus**

A new genus (diagnosis given below) was found to be related to *Eorupertia* and *Victoriella*, although it differs from them very noticeably in the shape of its test. Its only species is widely distributed in the Upper Eocene of Australia.

Maslinella chapmani Glaessner and Wade, **new species**

Plate 1, figures 7–8; plate 3, figures 4–8

Material: The South Australian material available consists of about fifty specimens from the Tortachilla limestone and the lower part of the Blanche Point marls at Maslin Bay and Witton Bluff, south of Adelaide; twenty-five specimens from Kingscote, Kangaroo Island; and sixty specimens from a sample from the Buccleugh group at 84 to 87 feet in bore KK52, Moorlands. Fourteen specimens were obtained from the Carnarvon Basin, Western Australia, at 1170 to 1175 feet in Rough Range South bore no. 1, 22°37′17″ S., 113°57′37″ E.

Description: Test large, lenticular, maximum diameter up to 2 mm., thickness to 1 mm. Large specimens have up to twelve chambers in the last whorl. Walls thick, clearly layered. As in most calcareous foraminifera, thickenings in the primary chamber wall are repeated by corresponding thickenings in the layers of shell material added to the test with each chamber. Thus a slight thickening at one edge of the apertural face is built up, on older chambers, into prominent, limbate "suture lines," which are seen in vertical sections as pillars (pl. 3, figs. 6–8). For convenience, the side with limbate sutures is here referred to as the dorsal. The opposite side, here called the ventral, has depressed sutures, somewhat straighter than the gently recurved dorsal sutures. The adult coiling is semi-involute, with a post-nepionic portion of up to fourteen or fifteen chambers arranged in one to one and one-half whorls. The inner ends of the dorsal sutures form a heavy ornamentation in the centre of the test. The dorsal side is the more convex unless exceptionally thick layers of shell material are laid over the ventral side (pl. 3, fig. 7b), building a mound in the umbilical region, which is usually occupied by a low boss with a dimpled surface. The peripheral margin is narrowly rounded to angular, often bluntly keeled on the older chambers. The aperture is a wide, low arch or slit along the basal suture, with a thick, rounded lip formed by the upturned edge of the apertural face above it. It extends on both sides of the periphery, often extending farther on the ventral side. Sometimes it extends farther on the dorsal side, as individual chambers may be tilted to one side or the other of a plane through the periphery. Nevertheless, the adult chamber arrangement as a whole is pseudo-planispiral. As new chambers are added, the ends of the aperture are covered, and its median portion remains to form the foramen.

The nepionic portion of the test has low trochospiral coiling and consists, most frequently, of three or four inflated chambers. One, possibly microspheric, specimen has seven nepionic chambers, also arranged in a low trochospiral coil (pl. 3, fig. 7). The succeeding adult chambers are arranged in a plane at right angles to the nepionic coil. The post-nepionic chambers are more or less angular at the periphery, giving the adult test its lenticular shape.

The wall structure is calcareous radiate and bilamellid, with the two lamellae separated, in section, by a thin dark zone. The septa are three-layered, consisting of the inner lining and the outer lamina of the previous chamber and the inner lining of the succeeding chamber. Interlocular spaces sometimes occur near the margins of the septa. The perforations are often deflected by the dorsal sutural thickenings, but pass through the ventral umbonal boss.

Dimensions of holotype and paratype (A.U.G.D. collection): Holotype (F15666): Maximum diameter 1.84 mm.; diameter at right angles to maximum 1.4 mm.; thickness 0.91 mm. Paratype (F15665): Maximum diameter 1.3 mm.; diameter at right angles to maximum 0.9 mm.; thickness 0.6 mm.

Remarks: Nepionic specimens appear almost identical with those of *Carpenteria rotaliformis* Chapman and Crespin that occur in the same sample. In post-nepionic chambers the shape differs markedly. There is no attachment area in the new species. This excludes it from *Carpenteria*, and the semi-involute, almost planispiral chamber arrangement differs equally from the rotaliform, high trochospiral genus *Eorupertia* and from the conical genus *Victoriella*. The resemblance of the adult *Maslinella* to *Anomalina* and similar genera is due to convergence in the adult growth stage.

Age: In all its known occurrences, *Maslinella chapmani* is accompanied by an Upper Eocene fauna. It is abundant and widespread in South Australia and extends to the Carnarvon Basin in Western Australia, but is not yet known in Victoria.

Hofkerina Howchin and Parr
Plate 1; figures 12–15

Hofkerina semiornata (Howchin) was described (as *Pulvinulina semiornata*) from the Miocene of Muddy Creek, near Hamilton, western Victoria (Howchin, 1889). In erecting the new genus *Hofkerina* for this species, Howchin and Parr (1931) assigned it to the Victoriellidae together with *Victoriella* and *Eorupertia*, stating that these were free relatives of the adherent *Carpenteria*. Galloway (1933) removed *Carpenteria* to the Rupertiinae, a move which was generally accepted, and placed *Hofkerina* in the Pegidiidae. Cushman (1940) followed Howchin and Parr in placing *Hofkerina* in the Victoriellidae. The holotype and six paratypes are in the palaeontological collections of the University of Adelaide. One of the paratypes was sectioned (pl. 1, fig. 14). In section, the most striking difference between it and the Victoriellidae is the fact that the perforations in the walls are very fine, contrary to the generic description which stated that they were coarse; they are also extremely numerous. *Hofkerina* has been figured quite accurately several times (Howchin, 1889; Howchin and Parr, 1931; Crespin, 1936), the figures clearly showing its regular trochospiral coiling, rather flat, ornamented dorsal side, rounded periphery, inflated ventral side, and foraminal pores. Some specimens have no umbilicus, a few have a slight umbilical depression, and in others openings lead from the umbilical area into the chambers of the last whorl. It appears that these openings were formed by resorption. In small specimens there is a small, arched foramen in the basal suture facing toward the umbilical area. One or more subsidiary foraminal pores extend along the basal suture toward the periphery, and a few pores appear in the septal face. In large specimens, only a row of foraminal pores is present along the suture, and many more pores are scattered over the septal face. In vertical sections (pl. 1, fig. 15), no axial spaces are seen, unlike the trochospiral Victoriellidae, which all have such spaces, separated from the chamber lumina, in an axial position. The wall structure of *Hofkerina* is radial and bilamellid. The presence of pillars in the dorsal walls seems to be the main feature that has been considered in allotting *Hofkerina* to the Victoriellidae. It does not seem to be a sufficient reason for including it in this family, in view of the different pores, apertural features, and lack of axial structures in *Hofkerina*. Cole's (1957) placing of *Hofkerina semiornata* in the genus *Eorupertia* is not supported by the present revision. Most of his figured material does not agree with any published figures or descriptions, nor with the type material of *Hofkerina semiornata* (Howchin). The position of *Hofkerina* remains uncertain; it may be related to *Pegidia*.

Corrosina Nyirö

In 1954 Nyirö described this genus, from the Upper Oligocene of Hungary, as calcareous, perforate, triangular in section, tapering toward the initial end, triserial, and somewhat irregular in size and in placing of chambers. He stated that the last whorl consists of three chambers, resembling the Globigerinidae to some extent. In Nyirö's opinion, the species *Rhynchospira abnormis* Hantken (1875), which Hantken previously (1871, 1873) had considered to be a *Globigerina*, belongs to his new genus. We disagree wih this opinion, as the species *Corrosina pupoides* Nyirö is small (up to 0.29 mm. long), the aperture is different, and no pillars are mentioned. It appears to belong to the Buliminidae.

DIAGNOSES OF THE GENERA OF THE VICTORIELLIDAE

Victoriella Chapman and Crespin, 1930, **emend.** Glaessner and Wade

Type species: Carpenteria conoidea Rutten, 1914.

Test conical, usually with a small attachment area near the apex. Juvenile stage free, trochospirally coiled, low-spired, consisting of a few subspherical chambers. A change in the direction of coiling corresponds with attachment, which may be permanent or temporary. In the adult stage the coiling is high-spired, with three or four subspherical chambers per whorl, not embracing, either with an umbilical depression or arranged around an axial hollow. Aperture umbilical, surrounded on three sides by a thick lip. Interlocular spaces may occur in the walls. Walls coarsely perforate (except for an imperforate area around the aperture), with pillars which displace the pores; wall structure calcareous radiate, bilamellid (consisting of an inner lining and an outer lamina which extends over the entire test when a new chamber is formed). No canals between the layers. Septa three-layered.

Maslinella Glaessner and Wade, **new genus**

Type species: Maslinella chapmani Glaessner and Wade, n. sp.

Test large, semi-involute, pseudoplanispiral; wall thick, calcareous radial, bilamellid, coarsely perforate except for the three-layered septa and the apertural face. Early chambers inflated, arranged as in low-spired *Globigerina*, later chambers arranged almost planispirally, with the axis of coiling at right angles to that of the first few chambers, and with a narrowly rounded to angular periphery. Aperture a wide, low, basal slit overhung by a thick, rounded lip.

Carpenteria Gray, 1858, **emend.** Glaessner and Wade

Type species: Carpenteria balaniformis Gray, 1858.

Test variable in shape; attachment area usually large, formed by the dorsal sides of all or most of the chambers. Coiling primarily trochospiral. Where known, microspheric generation attached throughout life but megalospheric nepionic specimens free, consisting of a spire of a few globular chambers. Attachment takes place early and persists throughout life. Growth remains trochospiral or becomes irregular; when irregular it may be directed away from the substratum or encrust it.

Chambers tend to be inflated; early adult whorls tend to be embracing. Aperture in the early stages basal or umbilical, surrounded on three sides by an arched lip, which often becomes tubular. Primary walls of chambers consist of two laminae, the inner of which may or may not completely enclose the chamber lumen, and the outer of which extends around the whole test. Walls coarsely perforate except near aperture. There are no pillars, but in large specimens there may be various complications of the wall, e.g., imperforate folds on the inside of the chamber walls (Carpenter, 1862), or grouping of the perforations into tubules in the outer part of the test walls. No canal system between the inner and outer laminae of the primary chamber walls, except perhaps in the type species.

Eorupertia Yabe and Hanzawa, 1925

Type species: Uhligina boninensis Yabe and Hanzawa, 1922. Test conical, cylindrical or irregularly elongate. Trochospiral, sometimes becoming irregular in a late growth stage. Attachment by the dorsal sides of most or all of the chambers, at least in a young growth stage. Umbilicate, with axial hollow. Aperture basal, slit-like, opening into the umbilicus, with an out-turned lip. Primary walls of chambers consist of two laminae separated by a narrow dark zone. The inner layer is usually absent from the centre of the septal face, and the outer one is extended around the whole test. Pillars are frequently developed in the outer walls. Walls perforate except in the area around the aperture. Septa usually partly three-layered and enclosing interlocular spaces near the outer edges. Reiss (1957*a*, p. 4) states: "Canal system septal-peristomal, with scattered communications to the outside through the main, outer lamella in the apertural region."

THE FAMILY VICTORIELLIDAE

Systematics and evolution

There is no doubt about the origin of the Victoriellidae from a trochospirally coiled bilamellid ancestor, but this form has not been identified. Most authors, from Galloway (1933) to Bermudez (1952) and Sigal (1952) have considered the genera now included in the Victoriellidae to be closely related to *Rupertia* (Eocene to Recent). We have no material of the latter genus available for investigation, but there is agreement about its close relationship with *Cibicides* in the nature of its attachment and in its structural characters. Nothing in the present investigation points to *Cibicides* as a possible ancestor of the Victoriellidae, and their resemblance to *Rupertia* is therefore considered to be not phyletic but convergent, and due to the similar attached mode of life of different trochospirally coiled, calcareous perforate foraminifera. Hagn (1955, p. 70) also found that *Eorupertia* could not be derived from *Rupertia* or from the Anomalinidae.

Smout (1955) considered *Sakesaria* a possible ancestor of *Rupertia* and the Victoriellidae, but this view was rejected by Reiss (1957*a*). Having examined *Sakesaria*, a member of the Rotaliidea *sensu stricto*, we agree with the latter author.

Reiss places the Victoriellidae in his "Superfamily Bilamellidea" because of the double layer forming the primary chamber walls. They differ from typical members of that superfamily in that the inner lining completely covers the septal face and forms three-layered septa in *Victoriella*, *Maslinella*, and some species of *Carpenteria*. Anisgard has reported this phenomenon in *Carpenteria bermudezi*, and Hagn's description (1955) of *Eorupertia* shows that three-layered septa may be formed in that genus also. This difference, however, concerns only the degree to which the inner lining is developed. The ultimate establishment of the position of the Victoriellidae among the "Bilamellidea" will depend on further investigation of the oldest and most primitive forms and on comparative studies of other "Bilamellidea" of Paleocene and Lower Eocene age.

It is remarkable that Carpenter (1862) recognized the resemblance of the early stages of *Carpenteria* to *Globigerina*, an early observation which we have confirmed and extended to *Victoriella* and *Maslinella*. Hantken (1871, p. 59; 1873, p. 224) originally listed *Victoriella abnormis* as a *Globigerina*.

From the ancestral form, which must have had inflated, subspherical chambers and bilamellid walls, the trend is toward attachment, which becomes an increasingly prominent feature in *Carpenteria*. In *Eorupertia* a small attachment area at least is maintained in later more advanced (and less "rotaliform") species. A curious change in the direction of coiling is observed in some forms of *Carpenteria*, in *Victoriella*, and in *Maslinella*. In the latter genus it is not connected with attachment but leads to pseudoplanispiral chamber arrangement. *Victoriella* may become entirely unattached. The absence of embracing chambers distinguishes *Victoriella* from *Eorupertia*, and the strong development of pillars separates it from *Carpenteria*. We are observing a plexus of genera with basically uniform wall structures, nepionic chamber arrangement, and apertural characters, but with different modes of growth in the adult stage. The various established genera cannot be distinguished by clear-cut characters that are valid for all of their species, and the differences between *Carpenteria hamiltonensis* and *Victoriella conoidea* appear to be less important than those between *Eorupertia boninensis* and *Eorupertia cristata*. It has been claimed that *Victoriella* is congeneric with *Eorupertia*,

but if this classification is accepted, the resulting genus must then be merged with *Carpenteria*. This lumping seems undesirable because of the different adaptational trend and long time-range of the latter genus.

Homotrema Hickson, *Sporadotrema* Hickson, and *Miniacina* Galloway are apparently related to *Carpenteria* as indicated by Hofker (1927, 1930), but they are much more highly specialized than the genera here placed in the Victoriellidae. Cushman (1940) placed them in a separate family, the Homotremidae. This seems to be the most satisfactory classification. The Homotremidae have bilamellid walls. Hofker (1927; 1930, p. 126) observed that there was no trace of a canal system in these genera, and that therefore they were not related to the Rotaliidea. The Homotremidae are descendants of *Carpenteria* that are specially adapted to attached life. They develop complex branching by the formation of multiple apertures and multiple chamber series and attain a very large size.

Diagnosis

It is now possible to give the following diagnosis of the family Victoriellidae:

Test thick-walled, mostly trochospiral, often adherent by the dorsal side in the nepionic or neanic stage and either remaining attached or becoming free-living in the adult stage, which differs in the direction of the axis of coiling in free-living forms. Walls calcareous, radiate, bilamellid, more or less coarsely perforate, frequently with pillars. Chambers subspherical, at least in the early stages. Aperture single, basal to umbilical, slit-like, arched with a thick lip, or tubular. Septal-peristomal canal system in *Eorupertia*. Interlocular spaces generally present, due to partial overlapping of depressions by layers of the chamber wall.

Stratigraphic and geographic distribution

Carpenteria ranges from Eocene to Recent. *Eorupertia* is known from the late Lower Eocene of France, from the Middle Eocene of France, Austria, Turkey, Iraq, Israel, and Oman, from the Middle to Upper Eocene of Assam, Western Australia, the West Pacific, and New Caledonia, and from the Upper Eocene of the Alps, the Carpathians, and Venezuela. It is also known from the Eocene of Italy.

Victoriella conoidea was first described from a limestone from northern New Guinea. *Eulepidina* cf. *dilatata*, *Lepidocyclina parva*, *Miogypsinoides* sp., *Heterostegina* sp., *Rotalia* sp., *Eponides* sp., *Cibicides* sp., and *Globigerina* sp. occur with it in the type slide. This limestone can be placed in the "*e*"-stage of the letter-classification of the East Indian Tertiary, representing approximately the Aquitanian or Chattian. In Australia the species was described (as *Carpenteria proteiformis* var. *plecte*) from the "Janjukian" of Torquay, Victoria. This horizon is now known as the Jan Juc formation; its age is considered to be Eocene by Crespin, who claims that *Hantkenina* occurs in it, but as others (including the present authors) have failed to find this or other Eocene index fossils at the same locality, and have recognized striking differences between the fauna of the Jan Juc formation and those of all *Hantkenina*-bearing beds, they consider its age Oligocene. This age is also assigned to beds in Gippsland (eastern Victoria), where the species is common (Crespin, 1943, 1950). In the Parr Collection, *Victoriella* is common in samples with similar faunas from the Aire Coast, southwestern Victoria. In the adjoining southeast portion of South Australia and in the Murray Basin it is common in the post-Eocene and pre-Miocene Gambier limestone and its equivalents (Ludbrook, 1957). The oldest recorded occurrences of *Victoriella conoidea* are from north of Blanche Point, Maslin Bay, South Australia (Crespin, 1954), and from the Johanna River limestone in southwestern Victoria (Crespin, 1956*a*). Crespin (1956*b*, pp. 39, 40) recorded "a small specimen of *Victoriella* cf. *plecte* Chapman" from the Upper Eocene of Balladonia, in the Western Australian part of the Eucla Basin. She stated: "It has been found with *Crespinella* sp. nov. and *Discocyclina* in the Carnarvon Basin." This and other references to *Crespinella* sp. nov. in the Eocene may be based on *Maslinella*, but we have not seen the material. Condon *et al.* (1956), referring to an unpublished report by Edgell, listed "*Victoriella plecte*" from the Middle to Upper Eocene Giralia limestone in northwestern Australia. Edgell meanwhile (unpublished thesis, Stanford University, 1954, pp. 224–226, pl. 18, fig. 1) has considered this occurrence as *Eorupertia boninensis*, and has stated his opinion that *Victoriella* is synonymous with *Eorupertia*. We have not seen the specimens on which these reports are based, but we have studied three specimens of *Victoriella conoidea* collected by Parr (N.M.V. slides 14963, 15017 and 15028) from strata in southwestern Victoria (Castle Cove; west of the mouth of the Aire River; and west of Cape Otway) that are considered to be uppermost Eocene.

Victoriella "*plecte*" has been reported from the Otaian stage in New Zealand. These beds are currently placed in the Upper Oligocene (Hornibrook, 1958).

Generalizing these data, we conclude that *Victoriella conoidea* ranges from the uppermost Eocene, where it is rare, through the Oligocene, where it is common. There is no evidence of *Victoriella conoidea* surviving

the Aquitanian. *Victoriella aquitanica* was described from the subsurface Aquitanian of the Aquitaine Basin. *Victoriella abnormis* occurs in Hungary commonly in the Upper Eocene "lower *Clavulina* beds" (now known as the Buda marl) with *Hantkenina kochi* (Hantken), and rarely in the Middle Oligocene "upper *Clavulina* beds" (Kiscell clay). It has also been reported from the Upper Eocene near Lake Garda, Italy (Hagn, 1956). An unidentified species was recorded by Reiss (1957*a*) from the Middle Oligocene of Israel. The stratigraphic distribution of the Victoriellidae is summarized in Table 1.

PLATE 1

All photographs unretouched (figure 15 composite). Figure 1 photographed by the Royal Melbourne Technical College.

1–5 *Victoriella "plecte"* (Chapman) = *Victoriella conoidea* (Rutten)

1, N.M.V. no. P13896, holotype of "*Carpenteria proteiformis* var. *plecte*" Chapman, from Torquay; 2, A.U.G.D. no. F15655, a large specimen with a very flat attachment area, from the Canopus bore; 3, A.U.G.D. no. F15656, from the Canopus bore, showing the floor of a chamber covering the depressed ventral sutures; 4, A.U.G.D. no. F15657, specimen with particularly small bosses and an oblique attachment area, from the Canopus bore; 5, A.U.G.D. no. F15654, small specimen with normal-sized bosses, from the Canopus bore. All from the Oligocene; × 25.

6 *Victoriella abnormis* (Hantken)

Showing small bosses, pointed apex, and (*b*) floor of last chamber covering the depressed ventral sutures and umbilical space, and folded to enclose a space behind the lip of the penultimate chamber; the foramen is infilled with sediment. Oligocene, Hungary; × 25.

7–8 *Maslinella chapmani* Glaessner and Wade, n. gen., n. sp.

7, A.U.G.D. no. F15666, holotype: a, ventral side, showing relatively straight, reclined, depressed sutures; the last chamber is aberrant, very narrow, and also broken at the periphery; b, apertural view; c, dorsal side, showing semi-involute coiling, limbate, raised, recurved sutures, and coarse perforations; 8, A.U.G.D. no. F15665, paratype: a, ventral view, showing large, central nepionic portion half surrounded by the first "adult" chambers; b, apertural view, showing foramen and angular periphery. Both from the Eocene of Maslin Bay; × 25.

9–11 *Carpenteria hamiltonensis* Glaessner and Wade, n. sp.

9, N.M.V. no. P17686, paratype, showing broad apex attachment area at lower left, and coarse perforations; 10, N.M.V. no. P17685, holotype, a median form showing coarse perforations and (*a*) change of ornamentation between young stage and last whorl remaining; *b*, attachment area; 11, N.M.V. no. P17684, paratype, a narrow, elongate specimen, showing foramen. All from the Eocene of Hamilton Creek; × ca. 20.

12–14 *Hofkerina semiornata* (Howchin)

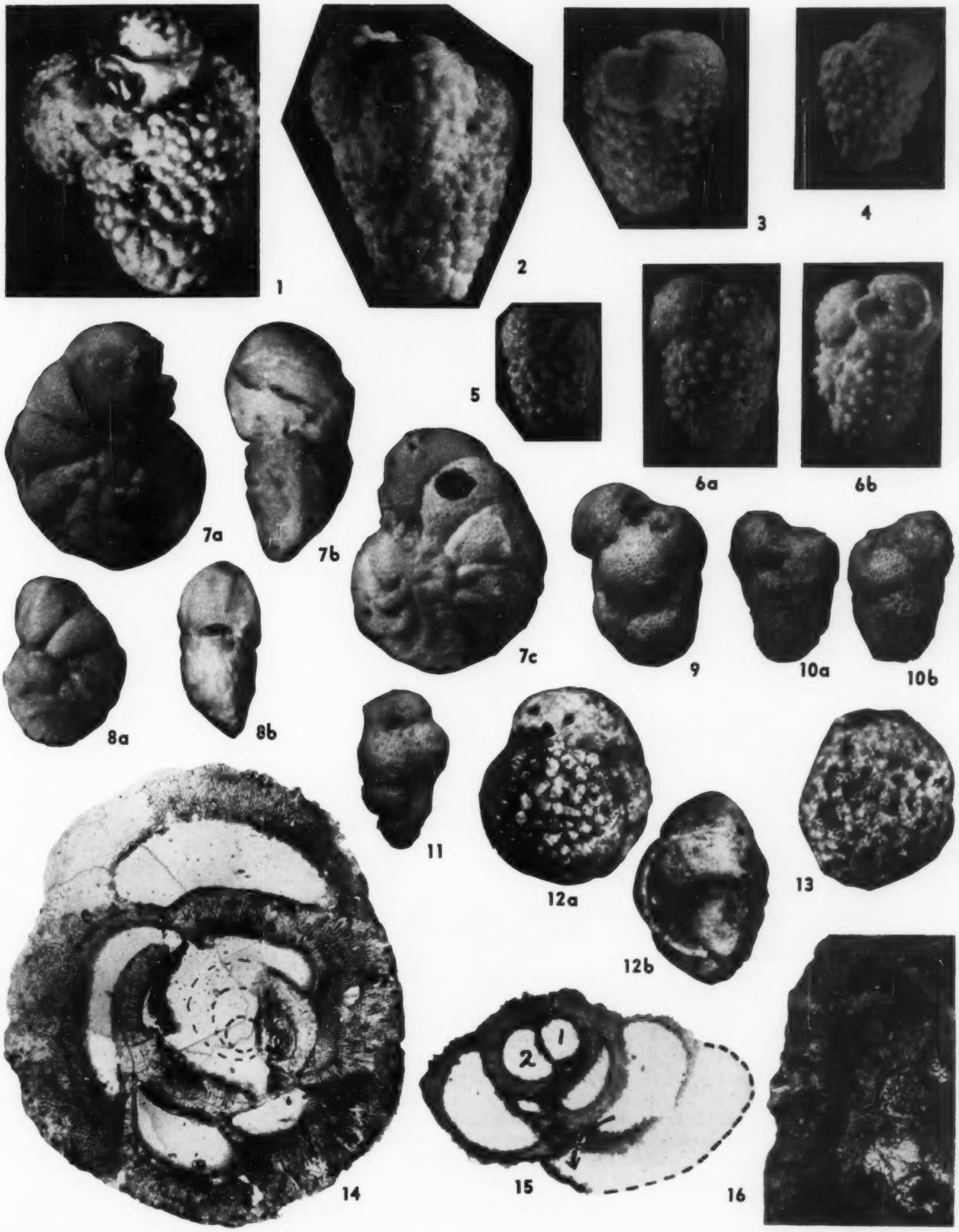
12, paratype, × 21: a, dorsal view, showing the bosses strongest on the older parts of the test; b, edge view into broken last chamber, showing thick wall and septal pores; 13, holotype, × 21, showing extremely heavy ornamentation on slightly worn dorsal side; 14, paratype, × 60, horizontal section at level of initial chamber, showing thick, bilamellid walls, very fine perforations, and (lower left) two pillars. All from the Miocene of Muddy Creek; A.U.G.D., Howchin collection.

15 *Hofkerina* sp. aff. *H. semiornata* (Howchin)

Vertical section, × 60, through first and second chambers; recrystallization masks the small dorsal pillars and the perforations; the oblique cut through the septum between the last two chambers spans the small apertural, foramen (at arrow); none of the subsidiary foraminal pores shows. Oligocene, 6 miles northwest of Mt. Gambier.

16 *Eorupertia cristata* (Gümbel)

A.U.G.D. no. F15664, showing fine pores in inner walls and coarse pores in outer walls. Eocene, Rollgraben, Bavarian Alps; × 60.


1
2
3
4
5
6a
6b
7a
7b
7c
8a
8b
9
10a
10b
11
12a
12b
13
14
15
16
1
2

BIBLIOGRAPHY

ANISGARD, H. W.
1956 – *Eorupertia in the Eocene of Venezuela.* Cushman Found. Foram. Res., Contr., vol. 7, pt. 2, pp. 48–59, pls. 9–12, text-figs. 1–5.
1957 – *Eorupertia bermudezi, a new foraminifer from the Middle Eocene of Cuba.* Cushman Found. Foram. Res., Contr., vol. 8, pt. 1, pp. 1–8, pl. 1, text-fig. 1.

BERMUDEZ, P. J.
1952 – *Estudio systemático de los foraminíferos rotaliformes.* Bol. Geol., vol. 2, no. 4, pp. 1–230, pls. 1–35.

CARPENTER, W. B.
1862 – *Introduction to the study of the foraminifera.* London: Ray Society, pp. 1–319, pls. 1–22, text-figs. 1–47.

CHAPMAN, F.
1921 – *Report of an examination of material obtained from a bore at Torquay.* Victoria, Geol. Survey, Rec., vol. 4, pt. 3, pp. 315–324, pl. 51.

CHAPMAN, F., AND CRESPIN, I.
1930 – *Rare foraminifera from deep borings in the Victorian Tertiaries – Victoriella gen. nov., Cycloclypeus communis Martin, and Lepidocyclina bornëensis Provale.* Roy.Soc. Victoria, Proc., vol. 42, pt. 2, pp. 110–115, pls. 7–8.

CHAPMAN, F., PARR, W. J., AND COLLINS, A. C.
1934 – *Tertiary foraminifera of Victoria, Australia: The Balcombian deposits of Port Phillip; Part III.* Linnean Soc. London, Jour., vol. 38, no. 262, pp. 553–577, pls. 8–11.

COLE, W. S.
1957 – *Larger foraminifera of Saipan Island.* U. S. Geol. Survey, Prof. Paper no. 280–I, pp. 321–360, pls. 94–118.

COLE, W. S., AND BRIDGE, J.
1953 – *Geology and larger foraminifera of Saipan Island.* U. S. Geol. Survey, Prof. Paper no. 253, pp. 1–45, pls. 1–15.

CONDON, M. A., JOHNSTONE, D., PRICHARD, C. E., AND JOHNSTONE, M. H.
1956 – *The Giralia and Marrilla Anticlines, North West Division, Western Australia.* Australia, Dept. Nat. Devel., Bur. Min. Resources, Bull. no. 25, pp. 1–86, pls. 1–7.

CRESPIN, I.
1936 – *The larger foraminifera of the Lower Miocene of Victoria.* Australia, Dept. Interior, Pal. Bull. no. 2, pp. 1–13, pls. 1–2.

PLATE 2

All photographs unretouched (figures 7–9 composite).

1–5 *Victoriella conoidea* (Rutten)

No. 922, slide no. D7279, Geological Institute, University of Utrecht: 1, the specimen figured by Rutten (1914, pl. 7, fig. 9) as *Carpenteria conoidea*, here designated as lectotype; 2–3, paratypes, figured by Rutten (1914, pl. 7, figs. 7–8); 4–5, paratypes, not previously figured: 4, showing the initial chamber just distal to an apical chamber; 5, showing an interlocular space extending from the center to the lower right, and an axial space below the last whole chamber preserved. All × 33.

6 *Carpenteria rotaliformis* Chapman and Crespin

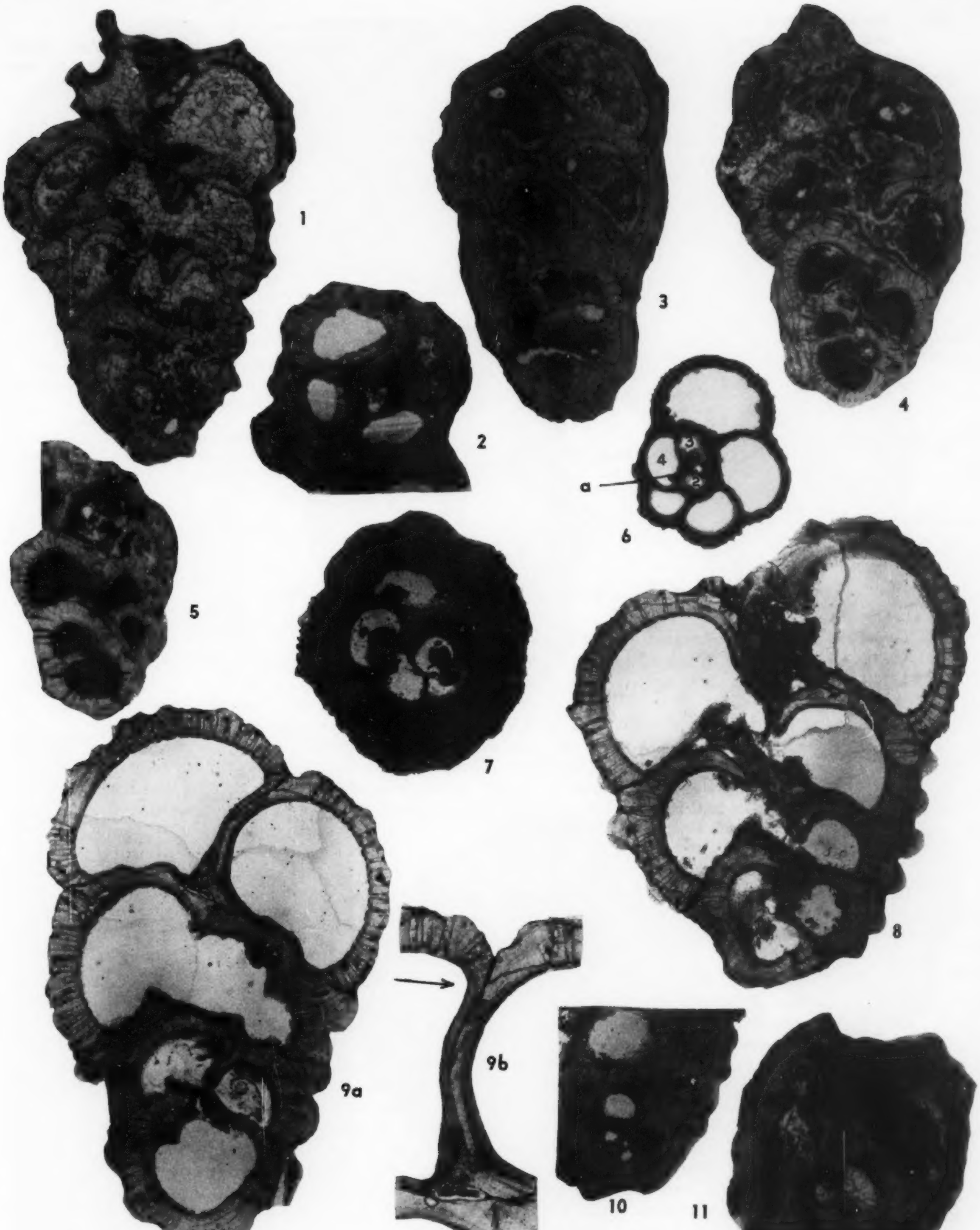
A.U.G.D. no. F15674, a thick horizontal section, viewed from the ventral side, × 33; one to four nepionic chambers, four adult chambers remain; *a*, foramen between first and second chambers. Oligocene to Mioccen, western Victoria.

7–10 *Victoriella "plecte"* (Chapman)

7, A.U.G.D. no. F15650, from southeastern South Australia, a horizontal section distal to the apex, × 60; clay infills the foramina between the first and second and between the third and fourth chambers; 8, A.U.G.D. no. F15652, from the Canopus bore, a vertical section, × 60, of a specimen in which the umbilicus is closed by overlapping chambers; 9, A.U.G.D. no. F15653, from the Canopus bore: a, section vertical to the initial whorl of the test and tangential to the remainder, × 60; the last chamber is present at the upper left, and the penultimate at the upper right; b, the same, × 110; the arrow points to the outer layer of the last chamber wall wedging out, and the inner layer thickens where it is applied to the imperforate two-layered septal face of the penultimate chamber, forming a three-layered septum; the outer wall of the penultimate chamber is thickened by additional material in optical continuity with its outer layer; a crack originates at the discontinuity between the outer layers of the last two chambers, and follows the line of weakness between the layers; 10, A.U.G.D. no. F15672, from southeastern South Australia, a microspheric specimen, × 60; initial whorl cut obliquely, probably at least seven chambers were present; strongly recrystallized. All from the Oligocene.

11 *Eorupertia cristata* (Gümbel)

A.U.G.D. no. F15663, a near-vertical section passing through the initial chamber, showing embracing whorls and layered walls. Eocene, Rollgraben, Bavarian Alps.


1
2
3
4
5
6
a
7
8
9a
9b
10
11

1943 – *The stratigraphy of the Tertiary marine rocks in Gippsland, Victoria.* Australia, Dept. Supply and Shipping, Min. Resources Survey, Pal. Bull. no. 4, pp. 1–101.

1950 – *Some Tertiary foraminifera from Victoria, Australia.* Cushman Found. Foram. Res., Contr., vol. 1, pts. 3-4, pp. 70–75, pl. 10.

1954 – *Stratigraphy and micropalaeontology of the marine Tertiary rocks between Adelaide and Aldinga, South Australia.* Australia, Dept. Nat. Devel., Bur. Min. Resources, Rept. no. 12, pp. 1–65, pls. 1–6.

1956*a* *Migration of foraminifera in Tertiary times in Australia.* Australia, Dept. Nat. Devel., Bur. Min. Resources, Rept. no. 25, pp. 1–15.

1956*b* *Fossiliferous rocks from the Nullarbor Plains.* Australia, Dept. Nat. Devel., Bur. Min. Resources, Rept. no. 25, pp. 26–42.

Cushman, J. A.
1940 – *Foraminifera, their classification and economic use.* Cambridge, Mass.: Harvard University Press, pp. 1–535, pls. 1–31, text-figs., tables and charts; Key, pls. 1–48.

Debourle, A., and Delmas, M.
1955 – *Victoriella aquitanica, nouveau foraminifère de l'Oligocène d'Aquitaine.* Soc. Géol. France, Bull., ser. 6, vol. 5, fasc. 1–3, pp. 47–49, pl. 1a, text-figs. 1–4.

Ellis, B. F., and Messina, A. R.
1940 *et seq.* – *Catalogue of Foraminifera.* New York: Amer. Mus. Nat. Hist., Spec. Publ., 30 vols. and supplements, ill.

Galloway, J. J.
1933 – *A manual of foraminifera.* Bloomington, Indiana: Principia Press, pp. 1–480, pls. 1–42.

Galloway, J. J., and Heminway, C. E.
1941 – *The Tertiary foraminifera of Porto Rico.* New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, pp. 275–491, pls. 1–36.

Glaessner, M. F.
1951 – *Three foraminiferal zones in the Tertiary of Australia.* Geol. Mag., vol. 88, no. 4, pp. 273–283.

Hagn, H.
1955 – *Zur Kenntnis alpiner Eozän-Foraminiferen; III – Eorupertia cristata (Gümbel).* Pal. Zeitschr., vol. 29, no. 1–2, pp. 46–73, pls. 4–6, text-figs. 1–2.

1956 – *Geologische und paläontologische Untersuchungen im Tertiär des Monte Brione und seiner Umgebung (Gardasee, Ober-Italien).* Palaeontographica, vol. 107, pt. A, pp. 67–210, pls. 7–18, text-figs. 1–8.

PLATE 3

Figures 1, 2a, 3, and 4 composite; figure 7b retouched.

1–2 *Carpenteria hamiltonensis* Glaessner and Wade, n. sp.

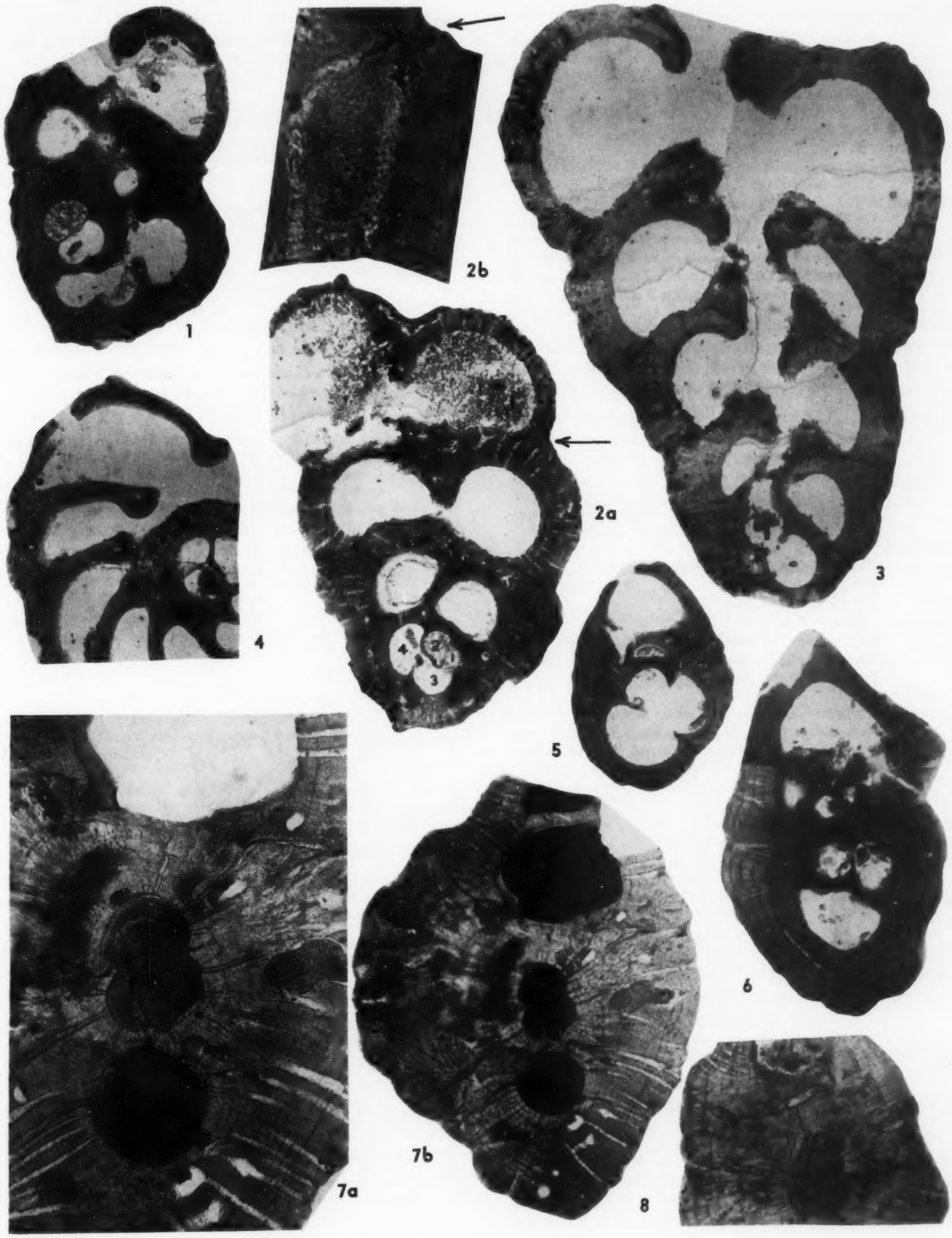
Vertical sections, showing laminated walls with coarse pores and scattered pieces of sponge spicules included: 1, N.M.V. no. P17687, a specimen with a wide apex similar to that in plate 1, figure 9, × 60; three nepionic chambers (at center left) are followed by three chambers forming part of a "rotalid" whorl; the remaining chambers were added three to a whorl; 2, N.M.V. no. P17688, the arrows pointing to the same pore: a, × 60 showing the early chambers, nos. 1 to 3 nepionic, no. 4 the first post-nepionic chamber; the arched lip of the foramen between the second and third chambers is below "2"; the organic lining of the chambers has contracted into the lumina in the next whorl; b, × 320, showing the diversion of a pore by the wall of the next whorl, so that it passes to the surface between adjoining chambers; such pores have been erroneously described as canals. Both from the Eocene of Hamilton Creek.

3 *Victoriella conoidea* (Rutten)

A.U.G.D. no. F15651, a vertical section, × 60, of a specimen with an axial hollow, also showing coarse pores and pillars; recrystallization partly obliterates layering in the walls. Initial chamber marked "1." Oligocene, southeastern South Australia.

4–8 *Maslinella chapmani* Glaessner and Wade, n. gen., n. sp.

4, A.U.G.D. no. F15671, from the Carnarvon Basin, a median horizontal section cut above the initial chamber, × 60, showing three-layered septa and thick apertural lips; 5–6, specimens from Maslin Bay, × 60; thick laminae in walls correspond to chambers: 5, A.U.G.D. no. F15667, section showing three nepionic chambers in horizontal section and adult chambers in vertical section; the foramen is visible at the basal part of the septum between two adult chambers; 6, A.U.G.D. no. F15668, a vertical section cutting one adult whorl, with two nepionic chambers in the center; pillars at left correspond to high, limbate dorsal sutures; diverted pores sometimes fuse; some early layers in the walls are poorly developed; 7, A.U.G.D. no. F15670, from the Carnarvon Basin, a vertical section of the adult and horizontal section of the nepionic portion, possibly microspheric: a, unaltered photograph, × 120; b, with chamber lumina darkened, × 67; 8, A.U.G.D. no. F15669, from Moorlands, a vertical section of the adult stage, with dorsal side to the left, × 60, showing numerous borings, particularly in the ventral wall of the test; similar borings are seen in *Carpenteria hamiltonensis* (fig. 2a) and *Victoriella conoidea*; lower part of septum and foramen visible near top. All from the Eocene.


1
2a
2b
3
4
5
6
7a
7b
8

HANTKEN, M.
1871 – *A budai Albrechtúton feltárt márgarétegek faunája.* Földt. Közl., vol. 1 (1872), nos. 4–5, pp. 57–63.
1873 – *Der Ofner Mergel.* K. Ungar. Geol. Anst., Mitt. Jahrb., vol. 2, no. 3, pp. 207–234.
1875 – *Die Fauna der Clavulina szaboi Schichten.* K. Ungar. Geol. Anst., Mitt. Jahrb., vol. 4, no. 1, 93 pp., 16 pls.

HANZAWA, S.
1957 – *Cenozoic foraminifera of Micronesia.* Geol. Soc. Amer., Mem. no. 66, pp. 1–163, pls. 1–38.

HICKSON, S. J.
1911 – *On Polytrema and some allied genera; A study of some sedentary foraminifera based mainly on a collection made by Professor Stanley Gardiner in the Indian Ocean.* Linnean Soc. London, Trans., Zool., ser. 2, vol. 14 (Reports of the Percy Sladen Trust Exped. to the Indian Ocean in 1905, vol. 3, no. 20), pp. 443–462, pls. 30–32, text-fig. 1.

HOFKER, J.
1927 – *The foraminifera of the Siboga Expedition; Part I.* Siboga-Exped., Monogr., no. 4, pp. 1–78, pls. 1–38, text-figs. 1–11.
1930 – *The foraminifera of the Siboga Expedition; Part II.* Siboga-Exped., Monogr., no. 4a, pp. 79–170, pls. 39–64, text-figs. 12–33.

HORNIBROOK, N. DE B.
1958 – *New Zealand Upper Cretaceous and Tertiary foraminiferal zones and some overseas correlations.* Micropaleontology, vol. 4, no. 1, pp. 25–38, pl. 1, tables 1–2.

HOWCHIN, W.
1889 – *The foraminifera of the Older Tertiary of Australia (No. 1, Muddy Creek, Victoria).* Roy. Soc. South Australia, Trans., vol. 12, pp. 1–20, pl. 1.

HOWCHIN, W., AND PARR, W. J.
1931 – *Notes on new and aberrant types of foraminifera.* Roy. Soc. Victoria, Proc., new ser., vol. 43, pt. 2, pp. 236–240, pl. 9.

LUDBROOK, N. H.
1957 – *A reference column for the Tertiary sediments of the South Australian portion of the Murray Basin.* Roy. Soc. New South Wales, Jour. Proc., vol. 90, pp. 174–180, table 1.

NAGAPPA, Y.
1956 – *Foraminifera of the genera Fabiania and Eorupertia from the Sylhet limestone of Assam.* Pal. Soc. India, Jour., vol. 1, pp. 191–198, pls. 30–31, text-figs. 1–4.

NYIRÖ, M. R.
1954 – *Nouveaux foraminifères oligocènes des couches chattiennes des environs de Budapest.* Földt. Közl., vol. 84, no. 1–2, pp. 67–74, 2 text-figs.

REISS, Z.
1957*a* *Notes on foraminifera from Israel; 5 – Studies on Victoriellidae.* Israel, Geol. Survey, [Bull.], pp. 1–9, pls. A–B, text-fig. 1.
1957*b* *The Bilamellidea, nov. superfam., and remarks on Cretaceous globorotaliids.* Cushman Found. Foram. Res., Contr., vol. 8, pt. 4, pp. 127–145, pls. 18–20, text-figs. 1–7, table 1.

REYNOLDS, M. A.
1953 – *The Cainozoic succession of Maslin and Aldinga Bays, South Australia.* Roy. Soc. South Australia, Trans., vol. 76, pp. 114–140, text-figs. 1–3, table 1, map.

RUTTEN, L.
1914 – *Foraminiferenführende Gesteine von Niederländisch Neu-Guinea.* Nova Guinea, Uitkomsten Nederl. Nieuw-Guinea-Exped. 1903, vol. 6 (Geol.), pt. 2, pp. 21–51, pls. 6–9, text-fig. 1.

SIGAL, J.
1952 – *Ordre des Foraminifera.* In: PIVETEAU, J., *Traité de Paléontologie.* Paris: Vol. 1, pp. 133–301.

SMOUT, A. H.
1955 – *Reclassification of the Rotaliidea (foraminifera) and two new Cretaceous forms resembling Elphidium.* Washington Acad. Sci., Jour., vol. 45, no. 7, pp. 201–210, text-figs. 1–10, 1 chart.

YABE, H., AND HANZAWA, S.
1922 – *Uhligina, a new type of foraminifera in the Eocene of Japan and West Galicia.* Japanese Jour. Geol. Geog., vol. 1, no. 2, pp. 71–75, pl. 12, text-figs. 1–4.

ABSTRACT: *Four species of a new fossil microspore genus are described. Their resemblance to certain extra-Australian fossil and living microspores is noted.*

On Schizosporis, a new form genus from Australian Cretaceous deposits

ISABEL C. COOKSON AND MARY E. DETTMANN
University of Melbourne
Melbourne, Australia

INTRODUCTION

The Australian Cretaceous microspores herein referred to the form genus *Schizosporis* are unusual amongst dispersed types in that they separate into two approximately equal parts along an equatorial line or furrow, apparently by natural means. A closely similar phenomenon is known to occur in the pollen grains of a few monocotyledonous and dicotyledonous species (Erdtman, 1952). However, since doubt exists as to the nature and origin of the forms comprising *Schizosporis*, it seems preferable that they should be referred to as microspores (in the comprehensive sense of the term) rather than as pollen grains.

Kuyl, Muller and Waterbolk (1955, pl. 5, figs. 1–4) recorded and figured fossil "pollen grains" from Lower Tertiary deposits in South America and Nigeria which appear to have the same general features as *Schizosporis*. Those authors distinguished two "types with equatorial furrows" by differences in sexinous sculpturing, but did not give either of the types generic status. Other fossil microspores, as far as can be judged from the illustrations published by Krutzsch (1957, table 3, figs. 33–48), may also have an affinity with *Schizosporis*. These comprise the spores from Middle European Cretaceous and Tertiary deposits which Krutzsch has assigned to the form genus *Ovoidites* Potonié, 1951. However, Professor Potonié, to whom we referred the present paper, is of the opinion that his genus *Ovoidites* is distinct from *Schizosporis*.

Furthermore, reference should be made to the superficial resemblance of *Schizosporis* to the figures given by Bolkhovitina (1956, table 9, figs. 119 and 124) of the Russian Cretaceous pollen species *Podozamites bilateralis* Bolkhovitina and *Psophosphaera clausa* Bolkhovitina. At present the morphographical interpretation suggested by Bolkhovitina for these two forms precludes the establishment of a connection between them and *Schizosporis*.

Four species of *Schizosporis* isolated from Cretaceous deposits in eastern Australia are described in this paper. The locations and ages of all but two of these deposits are cited in an earlier paper (Cookson and Dettmann, 1958, text-fig. 1). The new deposits are: 1) Carbonaceous shale from Haddon Downs bore no. 5 at 465 feet, northeastern South Australia; age Upper Cretaceous, (?Cenomanian), Winton formation (*fide* H. Wopfner, Geosurveys of Australia Ltd.); 2) South Australian Northern Territory Oil Search (Santos Ltd.) Oodnadatta bore no. 1 (*a*) at 47 feet, 87 feet, and 327 feet, age Lower Cretaceous, middle and upper Albian, Tambo formation; (*b*) at 743 feet, 842 feet, and 1052–1061 feet, age Lower Cretaceous, Aptian or older (age determinations by R. O. Brunnschweiler in an unpublished report for Santos Ltd.).

SYSTEMATIC DESCRIPTIONS

Genus **Schizosporis** Cookson and Dettmann, **new genus**

Microspores medium to large, with an equatorial line or furrow along which a separation into two approximately equal parts takes place.

Genotype: Schizosporis reticulatus Cookson and Dettmann, sp. nov.

Schizosporis reticulatus Cookson and Dettmann, **new species**
Plate 1, figures 1–4

Holotype: National Museum of Victoria palaeontological collection, no. P17710 (pl. 1, figs. 1–2).

Type locality: Haddon Downs bore no. 5, South Australia, at 465 feet.

Occurrence: South Australia: Robe bore at 4300 feet, 3860 feet, 3500 feet, 3325 feet, 3200 feet, and 3150 feet; Loxton bore no. 1 at 1410 feet; Cootabarlow bore no. 2 at 810 feet and 581 feet; Tilcha bore no. 1 at 1040 feet and

460 feet; Comaum bore at 708 feet; Haddon Downs bore no. 5 at 465 feet; and Oodnadatta bore no. 1 at 1052–1061 feet, 842 feet, 743 feet, 327 feet, and 87 feet, and bore no. 2 at 47 feet. Victoria: Dergholm bore no. 1 at 582 feet and 532 feet, and bore no. 2 at 329 feet; Berry Creek bore no. 18 at 278 feet; Wonthaggi State Coal Mine bore 175 at 760 feet, and West area floor of bottom seam; and Tyers River bore no. 2 at 1192–1197 feet. New South Wales: Onepah Station Well. Queensland: Styx Coal Measures Geological Survey bore no. 21 at 327 feet.

Spore large, equatorial diameter 90–135μ, biconvex, flattened at the poles, circular in polar view, elliptical in equatorial view, dividing equatorially into two approximately equal saucer-shaped sections. Exine 7–11μ thick, two-layered; sexine intectate, coarsely reticulate, lumina of reticulum five- or six-sided, muri *ca.* 1μ wide and 4–8μ high.

Known geological range: Lower to Upper Cretaceous (Neocomian – Aptian to ?Cenomanian).

Comments: Although *Schizosporis reticulatus* has a rather wide geographical and geological range in eastern Australia, it has appeared only in relatively small numbers in residues from the deposits listed above. It is found either as complete units, which may split equatorially when mounted, or as individual halves.

PLATE 1

All photographs are from unretouched negatives, and unless otherwise stated were taken at a magnification of *ca.* 400 diameters. The letter "P" preceding a number indicates that the specimen has been deposited in the palaeontological collection of the National Museum of Victoria, Melbourne.

1–2 *Schizosporis reticulatus* Cookson and Dettmann, sp. nov.
Surface view and optical section of holotype, P17710; Haddon Downs bore no. 5, South Australia, at 465 feet.

3–4 *Schizosporis reticulatus* Cookson and Dettmann, sp. nov.
Paratypes, from Haddon Downs bore no. 5, South Australia, at 465 feet, showing partial separation into two equal parts: 3, equatorial view; 4, polar view.

5 *Schizosporis rugulatus* Cookson and Dettmann, sp. nov.
An undivided paratype; Robe bore, South Australia, at 1400 feet.

6–7 *Schizosporis rugulatus* Cookson and Dettmann, sp. nov.
Polar and equatorial views of holotype, P17711; Robe bore, South Australia, at 1400 feet: 6, polar view after mounting; 7, equatorial view of complete spore prior to mounting.

8 *Schizosporis rugulatus* Cookson and Dettmann, sp. nov.
A partially split spore in equatorial view; Haddon Downs bore no. 5, South Australia, at 465 feet.

9 *Schizosporis rugulatus* Cookson and Dettmann, sp. nov.
Exine in surface view, × *ca.* 800.

10 *Schizosporis spriggi* Cookson and Dettmann, sp. nov.
A complete spore in polar view; Robe bore, South Australia, at 1400 feet.

11 *Schizosporis spriggi* Cookson and Dettmann, sp. nov.
Equatorial view of holotype, P17712; Oodnadatta bore no. 1, South Australia, at 87 feet.

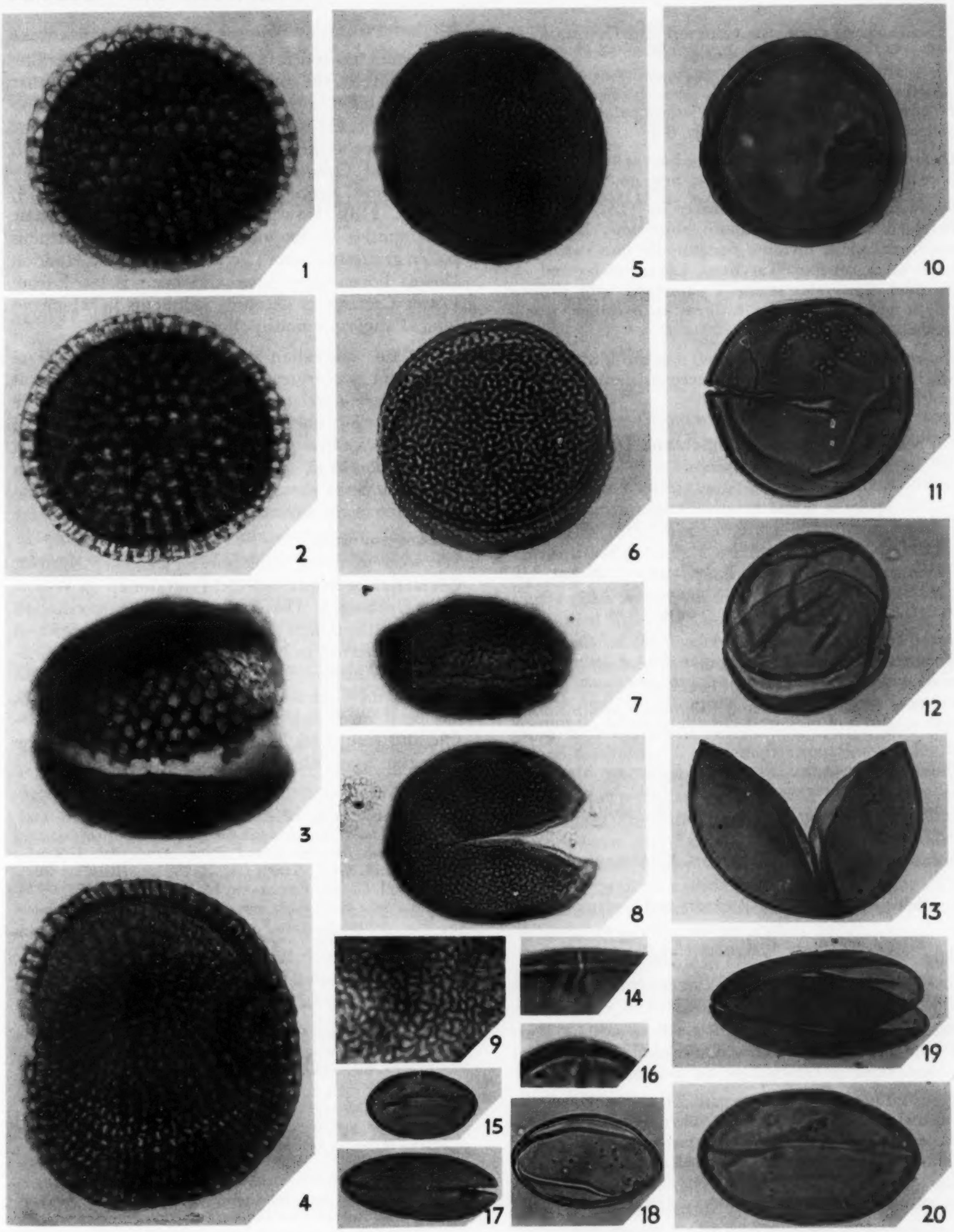
12–13 *Schizosporis spriggi* Cookson and Dettmann, sp. nov.
Polar and equatorial views; Haddon Downs bore no. 5, South Australia, at 465 feet.

14 *Schizosporis spriggi* Cookson and Dettmann, sp. nov.
Exine of holotype in optical section, showing equatorial split, × *ca.* 1800.

15, 20 *Schizosporis parvus* Cookson and Dettmann, sp. nov.
Holotype, P17713, in equatorial view; Haddon Downs bore no. 5, South Australia, at 465 feet: 20, × *ca.* 800.

16 *Schizosporis parvus* Cookson and Dettmann, sp. nov.
Optical section of exine, showing equatorial split, × *ca.* 1800.

17–19 *Schizosporis parvus* Cookson and Dettmann, sp. nov.
Paratypes in various stages of separation; Haddon Downs bore no. 5, South Australia, at 465 feet.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Schizosporis rugulatus Cookson and Dettmann, **new species**
Plate 1, figures 5–9

Holotype: National Museum of Victoria palaeontological collection, no. P17711 (pl. 1, figs. 6–7).

Occurrence: South Australia: Tilcha bore at 460 feet; Robe bore at 1400 feet; Haddon Downs bore no. 5 at 465 feet.

Spore large, equatorial diameter 82–112μ, biconvex, flattened at the poles, circular in polar view, elliptical in equatorial view, dividing equatorially into two equal boat- or saucer-shaped sections. Exine two-layered, *ca.* 2μ thick, intectate; sexine ornamented with sinuous ridges which may unite to form an irregular, small-meshed, shallow reticulum.

Known geological range: Schizosporis rugulatus is a rare type and has been found only in Cretaceous deposits of Albian and ?Cenomanian age.

Schizosporis spriggi Cookson and Dettmann, **new species**
Plate 1, figures 10–14

Holotype: National Museum of Victoria palaeontological collection, no. P17712 (pl. 1, fig. 11).

Occurrence: South Australia: Robe bore at 1400 feet; Tilcha bore no. 1 at 460 feet; Oodnadatta bore no. 1 at 87 feet; Haddon Downs bore no. 5 at 465 feet.

Spore large, equatorial diameter 78–125μ, circular in equatorial view, elliptical in polar view, splitting somewhat unevenly into boat- or occasionally saucer-shaped halves. Exine *ca.* 2μ thick, sexine thicker than nexine, with a faint and obscure LO pattern under oil immersion.

This species is named after Mr. R. C. Sprigg, Managing Director of Geosurveys (Australia) Ltd., by whom the samples from the Oodnadatta and Haddon Downs bores were made available.

Known geological range: Albian and ?Cenomanian.

Schizosporis parvus Cookson and Dettmann, **new species**
Plate 1, figures 15–20

Holotype: National Museum of Victoria palaeontological collection, no. P17713 (pl. 1, figs. 15–20).

Occurrence: South Australia: Robe bore at 1400 feet; Tilcha bore no. 1 at 460 feet; Oodnadatta bore no. 1 at 87 feet; Haddon Downs bore no. 5 at 465 feet.

Spore elliptical in both equatorial and polar views, splitting equatorially into two narrow, elongate boat-shaped sections; equatorial diameter 65–90μ, polar-diameter 35–50μ. Exine two-layered, *ca.* 2μ thick, sexine slightly thicker than nexine, very faintly patterned, smooth in optical section under oil immersion.

Known geological range: Albian and ?Cenomanian.

CONCLUSION

At present no conclusion can be reached regarding the affinity of the four species of *Schizosporis*, either with one another or with the microspores of living or fossil species. *S. spriggi* and *S. parvus* bear some resemblance to the pollen grains of *Rapatea spectabilis* Pilger and *Cephalostemon angustatus* Malme as described and figured by Erdtman (1952, p. 374, text-fig. 218). However, although both of these fossil species occur together with angiospermous pollen grains in Upper Cretaceous deposits (Haddon Downs bore), they have also been isolated from Lower Cretaceous (Albian) sediments in which no typical angiospermous pollen is evident.

All of the Australian species of *Schizosporis* are of infrequent occurrence and, as far as is known at present, are restricted to the Cretaceous. On the contrary, the unclassified South American and Nigerian "pollen grains" of Kuyl, Muller and Waterbolk (1955, p. 62, pl. 5, figs. 1–4), which appear to be of the *Schizosporis* type, are said to be abundant in the Lower Tertiary.

ACKNOWLEDGMENTS

We wish to thank Professor R. Potonié, Krefeld, Germany, for helpful advice; Professor H. T. Waterbolk, Groningen, The Netherlands, for information regarding the pollen grains from South America and Nigeria referred to herein; and R. C. Sprigg, Geosurveys (Australia) Ltd., Adelaide, for the Haddon Downs and Oodnadatta bore samples. This work has been subsidised by the Commonwealth Scientific and Industrial Research Organization and the Victorian State Electricity Commission.

BIBLIOGRAPHY

Bolkhovitina, N. A.
1956 – *Atlas of spores and pollen in Jurassic and Lower Cretaceous coals from the Viliuisk Basin.* Acad. Sci. U.R.S.S., Inst. Géol., Trav., fasc. 2, 185 pp. (Russian only).

Cookson, I. C., and Dettmann, M. E.
1958 – *Some trilete spores from the upper Mesozoic in the eastern Australian region.* Roy. Soc. Victoria, Proc., vol. 70, pp. 95–128.

Erdtman, G.
1952 – *Pollen morphology and plant taxonomy.* Waltham, Mass.: Chronica Botanica Co.

Krutzsch, W.
1957 – *Sporen und Pollengruppen aus der Oberkreide und dem Tertiär Mitteleuropas und ihre stratigraphische Verteilung.* Zeitschr. Angew. Geol., vol. 3, no. 11–12, pp. 509–548.

Kuyl, O. S., Muller, J., and Waterbolk, H. T.
1955 – *The application of palynology to oil geology with reference to western Venezuela.* Geol. en Mijnb., vol. 17, pp. 47–86.

Potonié, R.
1951 – *Revision stratigraphisch wichtiger Sporomorphen des mitteleuropäischen Tertiärs.* Palaeontographica, vol. 91, pt. B, pp. 131–151.

ABSTRACT: *A study of the foraminiferal content of samples from around Santa Catalina Island, California, reveals that the living and dead foraminifera can be divided into three depth zones, ranging from 0 to 20 fathoms, from 21 to 40 fathoms, and from 41 to more than 100 fathoms. Among the factors studied by the author, either temperature or depth or a combination of both is primarily responsible for this bathymetric distribution. Sedimentation and submarine topography were found to be important in the distribution of foraminifera in smaller areas.*

Foraminiferal biofacies around Santa Catalina Island, California

ROBERT H. McGLASSON
*University of Southern California**
Los Angeles, California

INTRODUCTION

Conditions affecting the distribution of foraminifera have been studied in several types of marine environments. These environments include brackish-water lagoons and marshes, bays, continental shelves and slopes, submarine banks, and basins. Prominently absent from this list are island shelves. The main purpose of this paper is to further increase the knowledge of foraminiferal distribution by an investigation of both living and dead foraminiferal populations around an offshore island, and the physical and chemical factors that might be an integral part of their particular distribution. These factors are depth, temperature, salinity, oxygen, types of sediment, submarine topography, and changes in sea level.

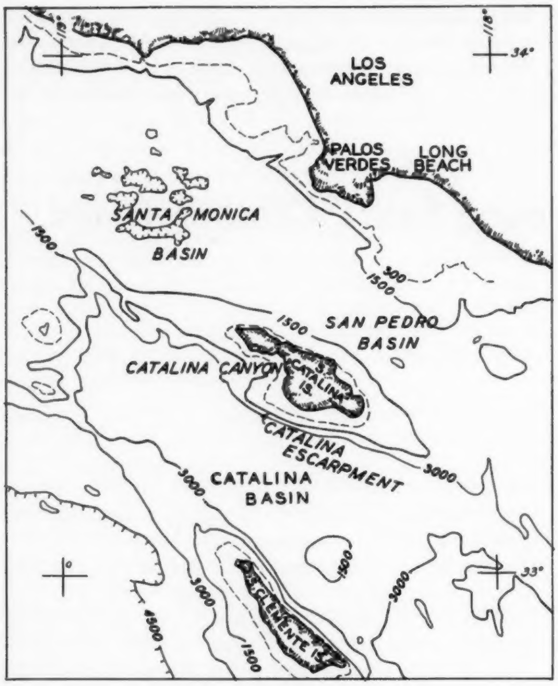
Santa Catalina Island is located approximately 25 miles south of Los Angeles Harbor, California (text-fig. 1). It is one of the larger members of the Channel Island group, which extends for almost 150 miles along the southern California coast.

Previous investigations

Several papers have been published concerning the ecology and distribution of foraminifera along the coasts of southern California and northwestern Mexico. The first work in the area was carried out by Moyer (MS.), who made a zonation of the Recent foraminifera found off San Pedro, California, as well as a comparison between Recent and fossil faunas. This was followed in 1933 by Natland's survey of the foraminifera found in a series of bottom samples across the San Pedro Channel. He established five foraminiferal zones that were based upon temperature and depth ranges. These zones and some of the abundant foraminifera are included in a later section of the present paper. Butcher (1951), in his report on Coronado Bank and vicinity, recognized several faunal depth boundaries, the principal ones being 290 and 440 meters. He believed that temperature has the greatest effect upon the distribution of foraminifera, salinity being a minor factor. Studies of foraminiferal displacement by turbidity currents were made by Phleger (1951). Cores recovered from eleven basins off the southern California coast were examined by Crouch (1952), who concluded that the nearly constant temperature present from sill level to the bottoms of the basins was responsible for the uniform faunas observed. Bandy (1953) studied the frequency distribution of foraminifera in sample profiles extending seaward from San Francisco, Point Conception, and San Diego, California. A bathymetric zonation was found to exist, along with north-south variation. Temperature appeared to be the dominant factor, except in a few cases. For example, shallow-water foraminifera found near San Diego occurred also in colder, deeper water near San Francisco. For comparison with the present author's results, Bandy's zonation of the traverse from San Diego seaward is given in a subsequent portion of the present paper.

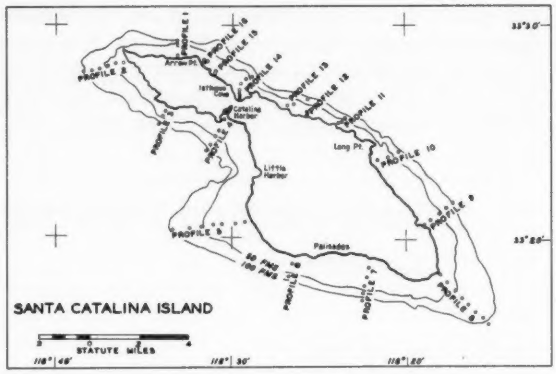
More recently, Walton (1955) has made a detailed analysis of living and dead foraminifera in Todos Santos Bay, Baja California, which includes salinity and temperature measurements as well as some sedimentary analyses. On the basis of the distribution and abundance of living benthonic foraminifera, four geographic assemblages were recognized (outer bay, middle bay, inner bay, and marginal bay), as well as four depth facies (less than 30 fathoms, 30 to 50 fathoms, 50 to 100 fathoms, and deeper than 350 to 400 fathoms). Variations in sediment types, food, depth, and temperature were thought to be the main factors governing foraminiferal distribution.

*Now with The Texas Company, Los Angeles, California.



TEXT-FIGURE 1

SANTA CATALINA ISLAND AND SURROUNDING SUBMARINE FEATURES



TEXT-FIGURE 2

LOCATION OF OFFSHORE PROFILES

Several taxonomic papers were also important in the present study. They are included in the bibliography.

Method of collection of samples

Seventy-one samples were collected by crew members and scientific personnel aboard the *Velero IV* during October 28, 29, and 30, 1955, and March 3 and 4, 1956. These samples were collected around Santa Catalina Island in a series of offshore profiles extending from as close to shore as possible outward to a depth of approximately 100 fathoms (text-fig. 2). Two sampling devices were used, the Hayward standard orange-peel grab and a snapper sampler. The former sampler was used whenever possible because of its larger capacity (2 cubic feet) and surface area (3 square feet). On the other hand, the snapper, with a surface area of 24 square inches and a capacity of approximately 1 pint, was used when quicker operations were necessary. A modified snapper that could be lowered and raised by hand was used to collect the nearshore samples from a launch.

Two samples were collected, either with the orange-peel grab (listed as O.P.G. in the appendix) or with the snapper sampler, at every station in the profiles (see Table 1). One sample was used for sedimentary analysis and the other for foraminiferal study. In order to collect as many foraminifera as possible, only about an inch of the top layer of sediment was removed, along with as much surface material as was deemed necessary. Isopropyl alcohol was added to preserve the protoplasm of the living foraminifera.

Laboratory preparation of samples

Foraminiferal analysis: Rose bengale, a red organic stain, was added to the samples preserved in alcohol. This was done as soon as possible, as the protoplasm, which stains a dark red color, tends to shrink over a period of time. Tests not stained by this process are those of dead individuals. After the stain had remained in the alcohol for a few hours, the solution was decanted and the sediment was dried, weighed, and then washed through a 250-mesh sieve (0.062 mm. screen opening) and dried again.

To facilitate counting, the foraminifera were concentrated by slowly adding the dried sediment to carbon tetrachloride. The unbroken foraminifera floated at the surface and were collected by carefully pouring the solution through filter paper. In order to assure complete separation, the residue left after decantation was examined for foraminifera. Many broken tests were found in some samples, and it was necessary to recombine the residue with the concentrate for counting purposes.

To obtain percentages of the various species, at least 250 dead benthonic individuals and accompanying planktonic forms were counted in each sample. Inasmuch as the samples contained a high concentration of foraminifera, it was necessary first to divide each sample with a modified Otto micro-splitter. The entire living population was counted in each sample, with the exception of about 25 per cent of

the samples, in which living forms were so abundant that splitting was possible.

Sedimentary analyses: Grain-size and calcium carbonate content analyses were made in order to determine the sediment types accurately. Sixty-nine of the previously mentioned samples were used, as well as twenty additional samples collected from previous cruises of the *Velero IV*.

The settling tube devised by Emery (1938), and the pipette method described by Krumbein and Pettijohn (1938), were used to determine the percentages of sand, silt, and clay. After the results of the analyses were plotted as cumulative curves on semilog paper, the median diameter and the 25 per cent and 75 per cent quartiles were calculated (see Table 3). Dilute hydrochloric acid was added to a small portion of each sample in order to determine the percentage of soluble calcium carbonate.

ACKNOWLEDGMENTS

The writer is greatly indebted to Drs. K. O. Emery and R. O. Stone for critical reading of the manuscript. Dr. Emery willingly gave his time and services in supervising the collection of samples. The Allan Hancock Foundation of the University of Southern California is to be thanked for making the *R. V. Velero IV* available for field collections, as well as for the use of its laboratory facilities. The writer is especially grateful to Dr. O. L. Bandy, the head of his guidance committee, for suggesting the topic and for constant supervision and helpful advice during the preparation of this paper.

GEOLOGY OF SANTA CATALINA ISLAND

Physiography

Santa Catalina Island, which is 22 miles in length and has a maximum width of 7½ miles, has a northwest-southeast trend that is in agreement with the fault patterns of the Peninsular Ranges physiographic province (Jenkins, 1943). However, the island can also be placed in a smaller unit, called the "continental borderland" by Shepard and Emery (1941). This unit is unique in that it represents a continental shelf consisting of alternating basins, troughs, banks, and islands, unlike the typical shelves found elsewhere throughout the world.

Topographically, the island is characterized by a well dissected ridge that extends the entire length of the island. The ridge, which is broken only by the narrow isthmus, is essentially flat-topped and has a maximum elevation of 2125 feet.

Marine terraces on the island are not as obvious as on some of the other members of the Channel Island group, but have been reported to exist by Smith (1933) and by Clements (1949, 1955). These authors believed that the terraces are not readily apparent because of their greater dissection and because they are composed of more resistant rock. On the other hand, Lawson (1898) and Shepard, Grant, and Dietz (1939) thought that no terraces exist. Marine shells found at an altitude of 1400 feet were reported as Pleistocene by Smith, thereby indicating Pleistocene or post-Pleistocene uplift. These shells were later reidentified as Miocene by Grant, showing that the uplift was Miocene or post-Miocene.

Steep cliffs undergoing present-day wave erosion as well as landsliding form most of the coastline. Some of these cliffs, which are found on the extreme southern portion of the island in the vicinity of the Palisades, rise to a height of over 1000 feet (text-fig. 2).

Lithology

The geology of Santa Catalina Island is little known as compared with the surrounding landmasses. To the writer's knowledge, only Smith (1897) and Woodford (1924) have done any appreciable field mapping and laboratory work. Three major rock types are found on the island, the most important of which is the Catalina metamorphic facies of the Franciscan series. This lithologic unit makes up the northwestern two-thirds of the island. Woodford stated: "These rocks are schistose, of variable grain, and made up largely of various combinations of the minerals quartz, albite, muscovite, chlorite, epidote, glaucophane, crossite, actinolite, and lawsonite." The other two principal rock types, volcanics and plutonic intrusive rocks of the southern California batholith, make up the southeastern third of the island. A small outcrop of Miocene(?) diatomaceous earth has been noted on the southeastern side of Isthmus Cove.

SUBMARINE AND OCEANOGRAPHIC CONDITIONS

Submarine topography

The major submarine features of the "continental borderland" surrounding Santa Catalina Island are the Santa Monica and San Pedro Basins to the northwest and north, respectively, and the Catalina Basin to the south and southeast (text-fig. 1). Of more immediate importance are the Catalina Escarpment, Catalina Canyon, and the insular shelf and slope.

The Catalina Escarpment, which comprises the southern slope of the island, is thought to form the northern border of a graben (Catalina Basin) lying between Santa Catalina and San Clemente Islands

TABLE 1

SAMPLES USED FOR FORAMINIFERAL AND SEDIMENTARY STUDY

Station number	*Latitude North*	*Longitude West*	*Depth in fathoms*	*Sampling device*
3569	33°29′15″	118°33′16″	100	O.P.G.
3570	33°28′58″	118°33′12″	48	O.P.G.
3571	33°28′30″	118°33′12″	15	Snapper
3572	33°27′47″	118°38′42″	103	O.P.G.
3573	33°27′50″	118°38′12″	88	O.P.G.
3574	33°28′00″	118°37′43″	53	Snapper
3575	33°28′02″	118°37′10″	44	O.P.G.
3576	33°28′10″	118°36′35″	36	O.P.G.
3577	33°28′15″	118°36′20″	15	Snapper
3578	33°25′10″	118°34′20″	140	O.P.G.
3579	33°25′36″	118°34′02″	48	O.P.G.
3580	33°25′50″	118°33′52″	40	O.P.G.
3581	33°24′05″	118°31′35″	100	O.P.G.
3582	33°24′21″	118°31′26″	65	Snapper
3583	33°24′43″	118°31′03″	50	Snapper
3584	33°25′00″	118°30′43″	48	O.P.G.
3585	33°25′30″	118°30′29″	23	O.P.G.
3586	33°25′55″	118°30′14″	4	Hand-sampler
3587	33°25′56″	118°30′15″	2	,,
3588	33°25′57″	118°30′16″	1	,,
3591	33°20′13″	118°33′17″	88	O.P.G.
3592	33°20′25″	118°32′15″	57	O.P.G.
3593	33°20′32″	118°31′58″	52	O.P.G.
3595	33°20′38″	118°31′07″	16	O.P.G.
3596	33°20′35″	118°30′38″	39	Snapper
3597	33°20′45″	118°29′45″	35	O.P.G.
3598	33°20′46″	118°29′22″	16	Snapper
3599	33°18′15″	118°26′49″	50	O.P.G.
3600	33°18′51″	118°26′33″	25	O.P.G.
3601	33°20′42″	118°19′08″	18	O.P.G.
3602	33°20′55″	118°18′45″	43	Snapper
3603	33°21′10″	118°18′22″	47	O.P.G.
3604	33°21′30″	118°17′53″	75	Snapper
3605	33°21′43″	118°17′33″	100	O.P.G.
3606	33°17′26″	118°22′33″	58	O.P.G.
3607	33°17′07″	118°22′45″	165	O.P.G.

TABLE 1 *(continued)*

SAMPLES USED FOR FORAMINIFERAL AND SEDIMENTARY STUDY

Station number	*Latitude North*	*Longitude West*	*Depth in fathoms*	*Sampling device*
3608	33°17′47″	118°22′25″	55	O.P.G.
3609	33°18′15″	118°22′14″	35	O.P.G.
3610	33°18′40″	118°22′17″	21	O.P.G.
3611	33°18′25″	118°18′06″	30	O.P.G.
3612	33°18′08″	118°18′48″	48	Snapper
3613	33°17′47″	118°17′24″	50	O.P.G.
3614	33°17′32″	118°17′00″	54	Snapper
3615	33°17′16″	118°16′35″	60	O.P.G.
3616	33°17′00″	118°16′10″	88	O.P.G.
3617	33°16′38″	118°15′48″	93	O.P.G.
3618	33°16′25″	118°15′25″	104	O.P.G.
3971	33°28′18″	118°31′37″	32	Snapper
3973	33°25′32″	118°23′42″	80	,,
3974	33°25′24″	118°23′53″	62	,,
3975	33°25′18″	118°24′05″	43	,,
3976	33°23′57″	118°20′34″	97	,,
3977	33°23′38″	118°21′05″	34	,,
3978	33°23′38″	118°21′50″	22	,,
3979	33°26′37″	118°25′42″	66	,,
3980	33°26′18″	118°26′36″	46	,,
3981	33°26′14″	118°26′50″	42	,,
3982	33°27′33″	118°28′55″	77	,,
3983	33°27′28″	118°29′21″	36	,,
3984	33°27′13″	118°29′42″	32	,,
3985	33°26′53″	118°29′43″	20	,,
3987	33°38′17″	118°31′42″	3	Hand-sampler
3988	33°28′15″	118°31′44″	2	,,
3989	33°27′45″	118°31′05″	6	,,
3990	33°27′49″	118°31′00″	10	,,
3991	33°26′33″	118°29′41″	4	,,
3993	33°26′41″	118°29′41″	13	,,
3994	33°26′29″	118°29′41″	2	,,
3995	33°25′41″	118°25′50″	1	,,
3996	33°25′42″	118°25′51″	4	,,
3997	33°25′43″	118°25′52″	8	,,

(Taber, 1927). Farther to the northeast, the scarp is offset by Catalina Canyon.

The head of Catalina Canyon is located one mile west of Little Harbor, where the principal drainage system of the island enters the ocean. The canyon, which curves slightly toward the southwest, extends from a depth of 300 feet to 3400 feet. In comparison with other submarine canyons along the California coast, Catalina Canyon is short as well as relatively steep, having a gradient of 14 per cent at the head and 6 per cent in the lower portion (Shepard and Emery, 1941).

The edge of the insular shelf is at a depth of approximately 300 feet. Other minor shelves or terraces are recognizable, but usually at greater depths, as shown by a series of profiles produced from fathometer soundings and United States Coast and Geodetic Survey soundings (Shepard and Wrath, 1937).

The width of the shelf is variable, being greatest off the southeastern tip of the island and in the area of Farnsworth Bank (Station 3595). On the whole, the shelf is wider on the windward side than it is on the leeward side, facing the mainland. Wave action ap-

pears to be the best explanation, as the windward side receives the full force of the waves, whereas the leeward side is more protected.

Oceanography

Oceanographic data concerning the shallow depths around Santa Catalina Island are meager. The only information available consists of seasonal measurements made at stations located off the coasts of southern California and Mexico by the Scripps Institution of Oceanography, temperature data from bathythermograph traverses made by personnel of the University of Southern California, a few measurements made by the author, and data from Natland's traverse across the San Pedro Channel (1933).

Two of the oceanographic stations maintained by the Scripps Institution of Oceanography are sufficiently close to Santa Catalina Island to be applicable in this report. One is located at latitude 33°24.5′ N., longitude 117°55′ W., the other lies at latitude 33°10.5′ N., longitude 118°23.5′ W. Although the stations are several miles to the southeast and southwest of the island, respectively, the salinity, temperature, and oxygen values for the various depths are considered to be approximately the same for the corresponding depths around the island (text-figs. 3 and 4). Readings for February, April, July, and September were used in order to indicate the annual variation. Most of the data compiled from the other sources fell within the range of annual variation, and need not be mentioned.

Salinity: Salinity, which has a minimum value of 33.37 parts per thousand at the surface, increases with depth to a maximum of 34.14 parts per thousand at 110 fathoms. The only major deviation is a slight decrease usually present near the surface. The annual range is small, with the greatest range occurring between the depths of 28 and 83 fathoms. No appreciable decrease in salinity would be expected to appear, because the runoff from the island is very small.

Oxygen: The oxygen content increases slightly from the surface to a maximum value of 6.23 milliliters per liter at a depth of 11 to 17 fathoms, and then decreases steadily to a minimum of 1.58 milliliters per liter at 110 fathoms. The annual range increases to depths of 41 to 55 fathoms, and then gradually decreases.

Temperature: Temperature shows considerable change with depth, decreasing from approximately 20° C. at the surface to a minimum of 7.98° C. at 110 fathoms. The annual variation, which is approximately 7° at the surface, rapidly decreases to 2° and less at a depth of 28 fathoms. Below this depth, the variation is small, usually less than one degree.

TABLE 2

SAMPLES USED FOR SEDIMENTARY STUDY ONLY

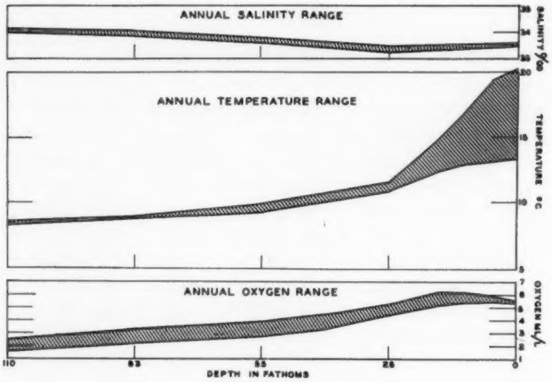
Station number	*Latitude North*	*Longitude West*	*Depth in fathoms*	*Sampling device*
2164	33°23′38″	118°21′52″	20	O.P.G.
2172	33°17′29″	118°29′13″	517	O.P.G.
2347	33°19′56″	118°16′15″	100	O.P.G.
2348	33°17′45″	118°16′21″	75	O.P.G.
2389	33°29′57″	118°34′04″	136	O.P.G.
2436	33°20′00″	118°18′00″	44	O.P.G.
2437	33°18′00″	118°18′00″	48	O.P.G.
2451	33°26′02″	118°24′00″	111	O.P.G.
2452	33°25′55″	118°26′04″	28	O.P.G.
2638	33°21′59″	118°20′00″	40	O.P.G.
2639	33°21′58″	118°18′01″	82	O.P.G.
2736	33°30′00″	118°36′02″	132	O.P.G.
2936	33°28′57″	118°36′48″	65	Snapper
2937	33°23′15″	118°31′48″	250	”
2938	33°17′16″	118°18′00″	50	”
2939	33°21′19″	118°18′08″	50	”
3017	33°22′46″	118°29′22″	24	”
3018	33°25′22″	118°31′03″	44	”
3040	33°27′22″	118°28′36″	98	”
3043	33°24′26″	118°18′11″	265	”
3992	33°26′37″	118°29′41″	8	”

Upwelling of cooler water occurs extensively off the northwestern coast of the island (Stevenson and Gorsline, personal communication). Upwelling has a pronounced influence upon plankton abundance because more nutrients are brought to the surface. In addition, because of decrease in the bottom temperature as well as in the surface temperature, benthonic animals may be affected. Minor occurrences of upwelling have also been noted in other areas around the island.

Currents: The direction of flow of currents around Santa Catalina Island is not well known. Some authors believe that they flow from northwest to southeast, but others believe they flow in the opposite direction. It is possible that both opinions are correct, the variable directions being attributable to changes in the prevailing winds during different seasons of the year.

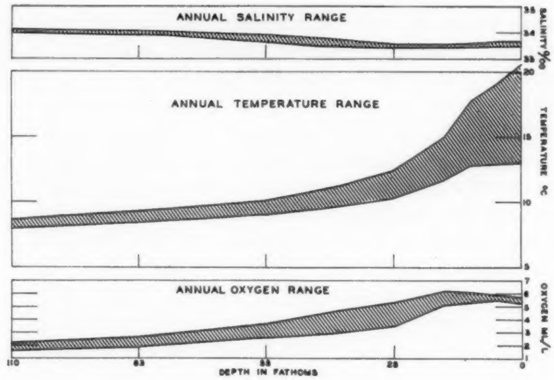
Sediment types

The sediments near Santa Catalina Islands are classifiable into two general categories, detrital and organic. Five types of sediment based upon texture



TEXT-FIGURE 3

Scripps station located at latitude 33°24.5′ N., longitude 117°55′ W. (southeast of Santa Catalina Island), showing the salinity, temperature, and oxygen variation with depth, and the annual range of each, during the year 1950.



TEXT-FIGURE 4

Scripps station located at latitude 33°10.5′ N., longitude 118°23.5′ W. (southwest Santa Catalina Island), showing the salinity, temperature, and oxygen variation with depth, and the annual range of each, during the year 1950.

are grouped under the former heading, including gravelly sand, sand, silty sand, sandy silt, and silt. The delineation of each type is illustrated by the boundaries shown in text-figure 5, which is the classification adopted by the personnel of the Allan Hancock Foundation as an aid in the description of sediments. Organic sediments are grouped on the basis of both chemical content and texture, and include only calcareous sand.

The majority of the sedimentary samples were green or some shade thereof, and hence color was not used to distinguish the various sediment types. Furthermore, no attempt was made to differentiate sand into fine, medium, and coarse, because of the scarcity of the latter two sizes.

The results of the sedimentary analyses are presented in Table 3. The reader is referred to Krumbein and Pettijohn (1938) for a complete discussion of the terms used.

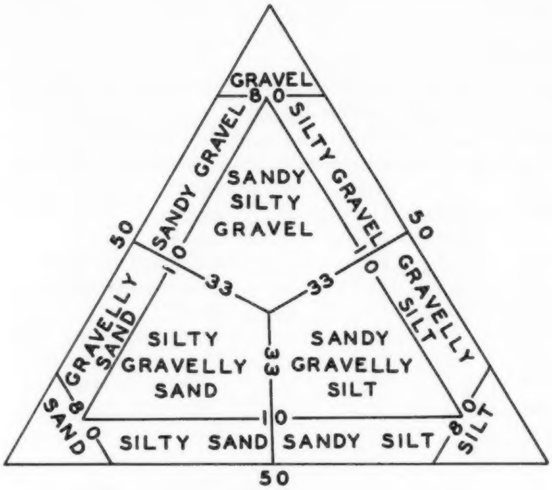
Because there are considerable distances between the various profiles, interpolation of sediment boundaries in the areal distribution map was necessary (text-fig. 6). Although this procedure introduces an error, it will suffice for a general survey. No detailed discussion of the sediment types will be given, as this topic is beyond the scope of the present paper. However, several statements and tentative conclusions can be made:

1) A band of sand, which is predominantly fine grained, is present in the nearshore area on the leeward side of the island, as well as at the northwestern and southeastern ends, but not on the windward side. Winnowing out of fine material by longshore currents on the leeward side may explain this distribution.

2) In general, fine-grained sediments are present in the more protected areas, such as canyons and indentations of the coast line that do not receive the full force of the currents. This phenomenon is best exemplified by the gradational sequence of fine sediments at the head of Catalina Canyon. Fine-grained sediments also occur southeast of Arrow Point and Long Point, apparently indicating a southeasterly current.

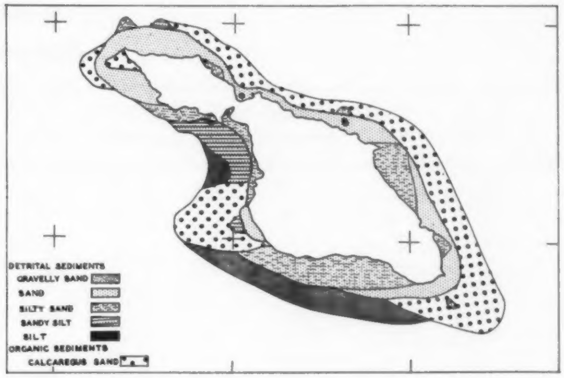
3) Grain size usually decreases with increasing depth, which is a function of the inability of waves to transport the coarser grades of sediment farther offshore (Shepard and Wrath, 1937).

4) The calcium carbonate content of the sediment increases with increasing depth, except for a few patches of *Lithothamnion* that occur in Isthmus Cove. This increase in calcium carbonate is related to an increase in the number of foraminifera (text-fig. 7). Smaller amounts of bryozoans, gastropods, *Lithothamnion*, and pelecypod shells are also present. Calcareous sand, which consists of at least 25 per cent calcium carbonate, is found predominantly on the outer shelf and slope around the island, except where detrital sedimentation appears to be dominant on the windward shelf and slope. An increase in grain size frequently occurs on the outer part of the shelf, probably due to large amounts of shell material.



TEXT-FIGURE 5

CLASSIFICATION OF SEDIMENT TYPES



TEXT-FIGURE 6

AREAL DISTRIBUTION OF SEDIMENT TYPES

DISTRIBUTION OF BENTHONIC FORAMINIFERA

The following study of the distribution of foraminifera is based upon frequency counts of both the living and dead populations found in the seventy-one samples recovered from the area surrounding Santa Catalina Island (text-fig. 2). Only forty-nine of the samples analyzed contained living specimens, which is indicative that there are areas around the island not populated by living foraminifera.

Bathymetric distribution of living and dead specimens

Composite frequency diagrams showing the average distribution of species around the island are presented in text-figures 8 and 9. In order to simplify the information contained in the diagrams, the average per cent of occurrence of the more important species is shown in Tables 4 and 5. Three depth zones, characterized by different faunal assemblages, can be distinguished, ranging from 0 to 20 fathoms, from 21 to 40 fathoms, and from 41 to more than 100 fathoms.

0 to 20 fathoms: Dead specimens, listed by species in order of decreasing abundance, are as follows: Species of miliolids, *Elphidium rugulosum*, *Discorbis monicana*, *Elphidium translucens*, *Bolivina quadrata*, *Textularia schencki*, and *Buliminella elegantissima*. The species of miliolids, *Elphidium rugulosum*, and *Buliminella elegantissima* are especially important at depths of approximately 10 fathoms and less, as they show a large decrease in percentage between 10 and 20 fathoms. Most of the miliolids are undifferentiated as to species because of the abundance of immature specimens. Only two species of miliolids, *Quinqueloculina bidentata* and *Quinqueloculina laevigata*, were found to make up an appreciable percentage, and then only in depths of 10 fathoms or less.

The distribution of living specimens in this depth range is somewhat different. The species represented, listed in order of decreasing abundance, are as follows: *Elphidium rugulosum*, *Nonionella basispinata*, *Textularia articulata*, *Quinqueloculina poeyana*, other species of miliolids, *Rotorbinella versiformis*, *Bolivina quadrata*, and *Buliminella elegantissima*. *Elphidium rugulosum* and species of miliolids, which are abundant in the dead population, are also common as living specimens in depths of approximately 10 fathoms and less. This is especially true of *Elphidium rugulosum*. *Buliminella elegantissima* and *Bolivina quadrata* were also found in both assemblages.

21 to 40 fathoms: As in the preceding depth range, the living and dead populations are essentially different. The dead assemblage consists of the following species: *Discorbis monicana*, *Bolivina quadrata*, *Elphidium translucens*, *Eggerella advena*, *Elphidium rugulosum*, species of miliolids, *Textularia candeiana*, and *Textularia schencki*. All of these species are equally important; they decrease in percentage to depths of approximately 40 fathoms, and never reappear in any considerable quantity. Species of *Cassidulina* begin to appear in great abundance, especially *Cassidulina subglobosa*.

Bolivina quadrata, *Nonionella basispinata*, and *Bolivina compacta* are living species characteristic of this depth range. Smaller percentages of *Buliminella elegantissima*, *Rotorbinella versiformis*, species of miliolids, and *Elphidium rugulosum* also occur. *Bolivina quadrata* is

TABLE 3

SEDIMENTARY DATA

Station number	*Median diameter*	*25°/o quartile*	*75°/o quartile*	*35°/o soluble in HCL*	*Classification*
3569	0.100	0.220	0.062	20.0	Sand
3570	0.105	0.140	0.077	15.1	Sand
3571	...	...	...	20.8	Sand
3572	0.190	0.310	0.125	41.6	Calcareous sand
3573	0.185	0.280	0.110	28.7	Calcareous sand
3574	0.340	0.475	0.250	19.8	Sand
3575	0.240	0.370	0.170	71.6	Calcareous sand
3576	0.740	1.170	0.380	25.2	Calcareous sand
3577	1.200	1.950	0.740	36.0	Calcareous sand
3579	0.078	0.145	0.034	14.5	Silty sand
3580	0.154	0.190	0.105	10.9	Silty sand
3581	0.038	0.056	0.016	10.9	Silt
3582	0.032	...	...	9.1	Sandy silt
3583	0.040	0.082	0.014	9.3	Sandy silt
3584	0.038	0.078	0.011	10.4	Sandy silt
3585	0.082	0.125	0.031	9.1	Silty sand
3586	0.125	0.170	0.050	6.0	Silty sand
3587	0.170	0.270	0.084	5.9	Sand
3588	...	...	...	22.7	Gravelly sand
3591	0.110	0.195	0.074	38.3	Calcoreous sand
3592	0.136	0.320	0.048	53.1	Calcareous sand
3593	0.130	0.250	0.045	43.8	Calcareous sand
3595	...	...	...	98.0	Calcareous sand
3596	0.350	...	...	27.6	Calcareous sand
3597	0.056	0.086	0.021	8.1	Sandy silt
3598	0.700	1.350	0.420	6.1	Sand
3599	0.090	0.250	0.054	11.0	Silty sand
3600	0.110	0.135	0.060	9.2	Silty sand
3601	0.138	0.170	0.110	17.2	Sand
3602	0.093	0.135	0.069	8.2	Sand
3603	0.100	0.135	0.080	29.2	Calcareous sand
3604	0.099	0.120	0.081	25.4	Calcareous sand
3605	0.175	0.310	0.100	35.9	Calcareous sand
3606	0.088	0.140	0.070	20.4	Sand
3608	0.069	0.083	0.045	12.1	Silty sand
3609	0.073	0.087	0.042	9.8	Silty sand
3610	0.077	0.089	0.062	8.7	Silty sand
3611	0.190	0.250	0.115	11.3	Sand
3612	0.090	0.120	0.070	13.3	Sand
3613	0.125	0.210	0.095	32.6	Calcareous sand
3614	0.168	0.275	0.108	58.6	Calcareous sand
3615	0.280	0.425	0.195	78.5	Calcareous sand
3616	0.163	0.280	0.097	42.5	Calcareous sand
3617	0.350	0.540	0.225	80.0	Calcareous sand
3618	0.140	0.215	0.112	29.1	Calcareous sand
3971	0.108	0.137	0.077	20.8	Sand
3973	0.225	0.670	0.093	22.8	Sand
3974	0.475	1.270	0.190	31.4	Calcareous sand
3975	0.116	0.128	0.084	8.4	Sand
3976	0.090	0.102	0.065	15.1	Silty sand
3977	0.125	0.215	0.074	22.1	Silty sand
3978	0.135	0.185	0.052	9.2	Silty sand
3979	0.330	0.600	0.190	47.7	Calcareous sand

TABLE 3 (*continued*)

SEDIMENTARY DATA

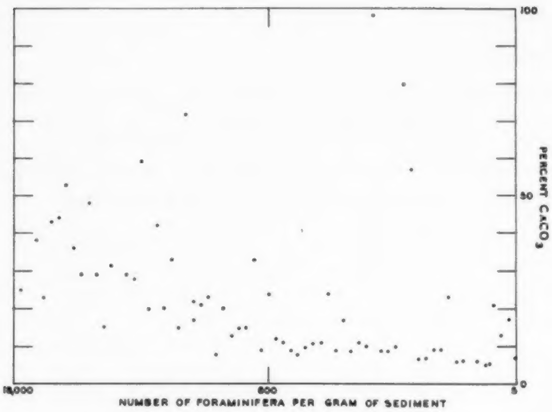
Station number	*Median diameter*	*25°/o quartile*	*75°/o quartile*	*35°/o soluble in HCL*	*Classification*
3980	0.110	0.156	0.091	25.9	Calcareous sand
3981	0.145	0.220	0.125	15.0	Sand
3982	1.050	1.630	0.690	80.1	Calcareous sand
3983	0.295	0.560	0.200	32.8	Calcareous sand
3984	0.170	0.360	0.139	25.1	Calcareous sand
3985	0.190	0.360	0.135	23.8	Sand
3987	...	...	...	17.3	Gravelly sand
3988	0.107	0.178	0.046	5.1	Silty sand
3989	0.056	0.135	0.010	7.3	Sandy silt
3990	0.120	0.227	0.030	7.4	Silty sand
3991	...	...	...	57.2	Calcareous sand
3992	...	...	...	93.7	Calcareous sand
3994	0.180	0.235	0.135	12.6	Sand
3995	0.190	0.250	0.145	7.4	Sand
3996	0.163	0.220	0.120	10.4	Sand
3997	0.142	0.205	0.084	8.7	Sand
2164	0.100	0.180	0.047	10.6	Silty sand
2172	0.018	0.052	0.003	19.7	Silt
2347	0.091	0.120	0.069	27.8	Calcareous sand
2348	0.160	0.300	0.088	60.3	Calcareous sand
2389	0.046	0.072	0.032	20.5	Sandy silt
2436	0.085	0.120	0.060	11.8	Silty sand
2437	0.091	0.123	0.068	11.9	Sand
2451	0.062	0.090	0.040	16.4	Silty sand
2452	0.124	0.202	0.091	13.2	Sand
2638	0.100	0.128	0.074	12.1	Silty sand
2639	0.087	0.121	0.063	30.5	Calcareous sand
2736	0.066	0.105	0.037	21.2	Silty sand
2936	0.116	0.165	0.070	17.9	Sand
2937	0.038	0.058	0.009	18.9	Silt
2938	0.054	0.065	0.036	10.3	Sandy silt
2939	0.093	0.180	0.066	47.3	Calcareous sand
3017	0.110	0.210	0.057	14.3	Silty sand
3018	0.032	0.055	0.009	7.3	Silt
3040	0.068	0.105	0.042	25.2	Calcareous sand
3043	0.054	0.093	0.032	25.1	Calcareous sand

abundant in both the dead and living populations, especially in the latter. Species of miliolids and *Elphidium rugulosum* make up a much smaller percentage in both assemblages than in the 0 to 20 fathom depth range.

41 t greater than 100 fathoms: Little comparison can be made between the living and dead populations. The dead population is characterized by an abundance of *Cassidulina tortuosa*, *C. subglobosa*, *C. minuta*, and *C. limbata*. These species comprise 50 to 60 per cent of the total dead foraminiferal population. *Cassidulina tortuosa* shows a steady increase in abundance to depths of greater than 100 fathoms, whereas the other species of *Cassidulina* are more uniformly distributed on the shelf and slope. *Cibicides mckannai* is also important.

The living population is characterized by a great abundance of *Bolivina pacifica* and *Cancris sagra*, particularly the former species. *Bolivina pacifica* increases in percentage of abundance with increasing depth, whereas *Cancris sagra* appears to decrease at depths of 100 fathoms and greater. Other species common in this depth range are *Hanzawaia nitidula*, *Bolivina acuminata*, *Bolivina tongi*, and *Angulogerina angulosa*.

Non-indicative species: Dead specimens not indicative of any particular depth range within the scope of this investigation, but usually more abundant on the



TEXT-FIGURE 7

RELATIONSHIP OF CALCIUM CARBONATE TO NUMBER OF FORAMINIFERA PER GRAM OF SEDIMENT

outer portions of the shelf, belong to the following species: *Angulogerina angulosa*, *Angulogerina baggi*, *Bolivina acuminata*, *Bolivina pacifica*, *Bolivina pseudoplicata*, *Bulimina denudata*, *Cancris sagra*, *Cibicides fletcheri*, *Epistominella bradyana*, *Gaudryina arenaria*, *Planulina ariminensis*, and *Rotorbinella versiformis*.

Living species not indicative of any particular depth range are *Bolivina acutula*, *Cassidulina subglobosa*, *Cassidulina minuta*, *Bulimina denudata*, and *Epistominella bradyana*. However, *Bolivina acutula* is more abundant between the depths of approximately 15 and 60 fathoms.

Ratios of living to dead specimens: The relationship between living and dead foraminifera (the L/D ratio) is best shown by a formula devised by Walton (1955):

$$R = \frac{\text{living population}}{\text{dead population}} \times 100$$

Because of the great quantity of dead specimens in the Santa Catalina samples, the living population was multiplied by a factor of 1000 instead of 100.

L/D ratios vary from O, in which no living species were encountered, to a maximum of 271.2 (see Table 6). The areal distribution map (text-fig. 10) shows a steady increase in the L/D ratios toward the shoreline, especially in those areas where nearshore samples were obtained. This is apparently the result of dilution of the dead specimens in the shallower areas by the faster deposition of detrital sediments (Walton, 1955). L/D ratios can therefore be used in establishing relative rates of sedimentation; this relationship is discussed in greater detail in the following section.

The offshore area near the Palisades is unusual in that the L/D ratios are higher than ordinary at a greater distance from shore. The coastline is evidently being eroded at a faster rate there than in other areas.

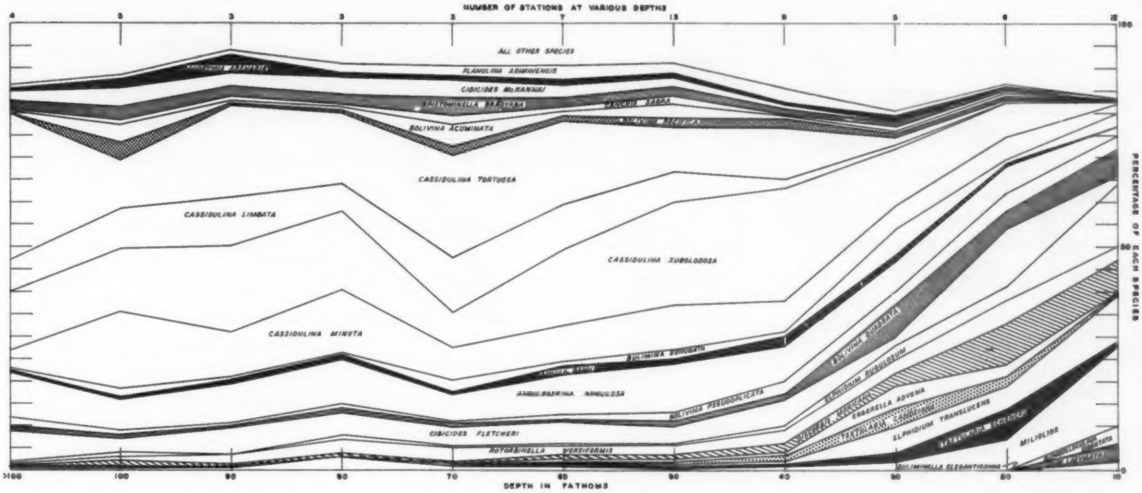
Use of foraminifera in the determination of relative rates of sedimentation

Relative rates of sedimentation can be measured by two processes that involve a study of foraminifera: L/D ratios, and the determination of the total number of foraminifera per gram of sediment. The former method was mentioned previously, and will be compared with the latter process in the following discussion.

The foraminifera per gram of sediment were calculated by first obtaining the dry weight of the sample, next processing the sample, and then counting the total number of foraminifera in one fraction of the concentrate as determined by dividing the sample with a micro-splitter. Each fraction thus examined was multiplied by a factor which depended upon the number of times the sample had been split. If the sample had been divided four times, then the final fraction represents 1/16 of the original amount, and must be multiplied by 16. The total number of foraminifera was then divided by the dry weight of the original sample.

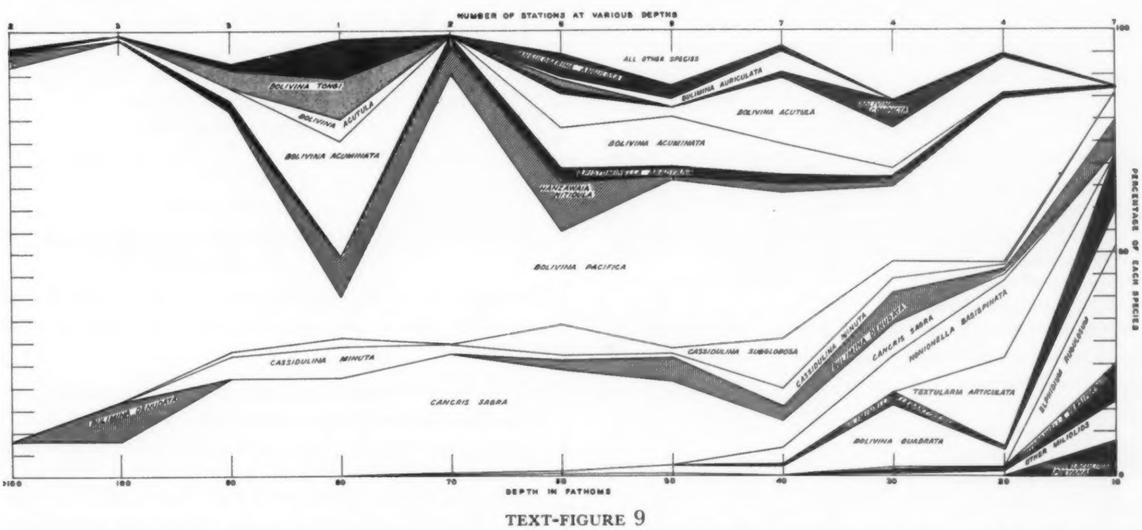
Generally speaking, there is a large increase in the number of foraminifera with increasing distance from shore (text-fig. 11). This increase is comparable with the low offshore L/D ratios, in that both findings suggest that faster sedimentation occurs close to shore, whereas a very slow rate occurs on the outer shelf and slope. Samples containing few foraminifera are particularly close to shore except in the shelf area adjacent to the Palisades, where the rate of sedimentation is shown by both methods to be faster.

The number of foraminifera per gram of sediment and the L/D ratios are not always comparable. They were found to differ in two cases: (1) On Farnsworth Bank, sedimentation as shown by the number of foraminifera is faster than the rate indicated by the very low L/D ratios; and (2) on the shelf and slope near Catalina Harbor, the rate of sedimentation is shown by the number of foraminifera to be considerably faster. However, in this case, most of the stations did not contain living foraminifera, and the L/D ratios therefore indicate very slow deposition.



TEXT-FIGURE 8

COMPOSITE FREQUENCY DIAGRAM SHOWING AVERAGE DISTRIBUTION OF DEAD SPECIMENS AROUND SANTA CATALINA ISLAND



TEXT-FIGURE 9

COMPOSITE FREQUENCY DIAGRAM SHOWING AVERAGE DISTRIBUTION OF LIVING SPECIMENS AROUND SANTA CATALINA ISLAND

Test types

Composite frequency diagrams illustrating the effect of depth upon the three types of foraminiferal tests (arenaceous, hyaline, and porcellanous) are shown in text-figure 12. The living and dead assemblages show the following trends:

1) Porcellanous species, which are very abundant at depths of approximately 10 fathoms and less, decrease with increasing depth in both living and dead populations. Living porcellanous species were not observed at depths greater than 50 fathoms.

2) Arenaceous species are generally more abundant near shore, but not especially in very shallow water or at depths less than 15 fathoms. In both living and dead populations, the maximum number of arenaceous species occurs at 30 fathoms. Living species were not found any deeper than 80 fathoms.

3) Hyaline species, which make up the majority of the foraminifera at all depths, exhibit a steady increase in percentage with increasing depth. In depths greater than 80 fathoms, the entire living population consists of hyaline species.

TABLE 4

AVERAGE PERCENTAGES OF DEAD SPECIMENS

	0–20 fathoms	21–40 fathoms	41–>100 fathoms
Species of miliolids	16	1	1
Elphidium rugulosum	9	2	<1
Discorbis monicana	8	3	<1
Elphidium translucens	8	3	<1
Bolivina quadrata	5	3	<1
Textularia schencki	4	1	<1
Buliminella elegantissima	1	–	–
Eggerella advena	2	3	<1
Textularia candeiana	1	3	<1
Cibicides mckannai	–	1	3
Cassidulina limbata	–	1	8
Cassidulina minuta	4	6	10
Cassidulina subglobosa	4	19	16
Cassidulina tortuosa	<1	7	19

TABLE 5

AVERAGE PERCENTAGES OF LIVING SPECIMENS

	0–20 fathoms	21–40 fathoms	41–>100 fathoms
Elphidium rugulosum	14	<1	–
Nonionella basispinata	10	6	–
Textularia articulata	10	–	–
Quinqueloculina poeyana	6	–	–
Species of miliolids	6	<1	<1
Rotorbinella versiformis	6	<1	<1
Bolivina quadrata	6	8	<1
Buliminella elegantissima	6	2	–
Bolivina compacta	–	4	<1
Bolivina tongi	–	–	2
Angulogerina angulosa	<1	<1	3
Hanzawaia nitidula	–	2	4
Bolivina acuminata	–	5	7
Cancris sagra	<1	7	18
Bolivina pacifica	19	20	48

Very few trends are noticeable in the diagrams illustrating the effect of grain size upon the distribution of foraminiferal tests (text-fig. 13). However, porcellanous species are more common in sediments having a median diameter greater than 0.500 mm.

Faunal relationships to previously established zones

Two important contributions concerning the zonation of Recent Foraminifera in the offshore area of southern California were made by Natland (1933) and by Bandy (1953). As a supplement to their observations, a comparison is made between their zonations and the bathymetric distribution of the dead foraminifera around Santa Catalina Island.

Natland recognized the following zones, which include fossil as well as Recent foraminifera:

Zone I. Shallow brackish-water lagoon.
Abundant: *Streblus beccarii.*

Zone II. Bottom-temperature range 21.43° C. – 13.20° C.
Depth range 14–125 feet.
Abundant: *Nonion scapha*
Elphidium articulatum
Elphidium hannai
Elphidium hughesi
Elphidium spinatum
Buliminella elegantissima
Eponides ornatus
Nonionella basispinata

Zone III. Bottom temperature range 13.20° C. – 8.50° C.
Depth range 125–900 feet.
Abundant: *Cassidulina californica*
Cassidulina limbata
Cassidulina tortuosa
Eponides repandus
Quinqueloculina akneriana
Polymorphina charlottensis
Robertina charlottensis
Sigmomorphina frondiculariformis
Triloculina trigonula

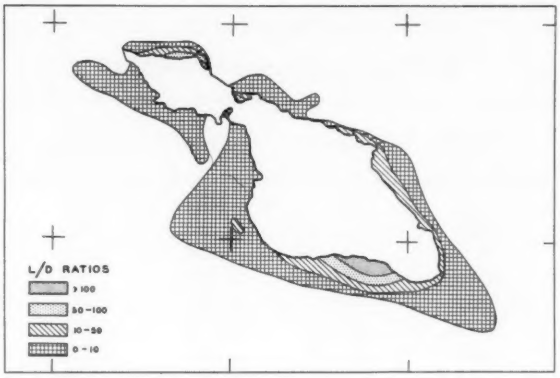
It is not necessary to include the characteristics of zones IV and V because this study does not involve these zones.

Because species of *Cassidulina* are very abundant in the area studied by the author and are present in the appropriate depth range, zone III is well represented. Zone I is indicated by the very meager occurrence of *Streblus tepidus*, and zone II by *Buliminella elegantissima* and *Nonionella basispinata*. Other forms listed as common by Natland were found to be rare or absent.

Bandy's zonation of a traverse extending from San Diego is as follows:

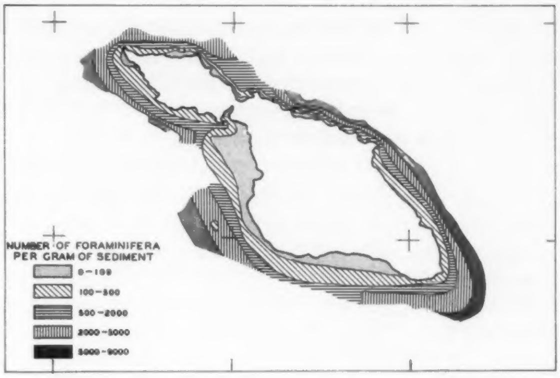
Middle neritic zone 40–100 feet, 13–17.5° C., salinity 33.3 parts per thousand, oxygen 5.2 – 6.4 milliliters per liter.

(0–150 feet) *Nonionella basispinata*
Trochammina pacifica
Nonionella miocenica var. *stella*
Rotorbinella lomaensis
Elphidium translucens



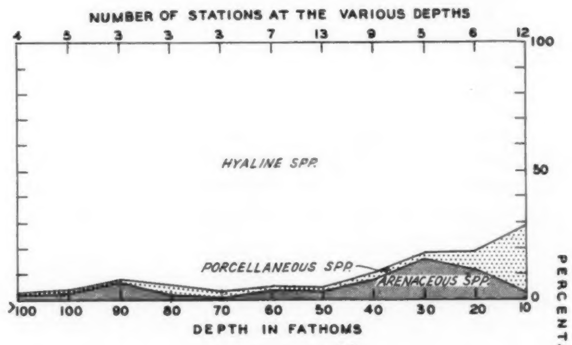
TEXT-FIGURE 10

AREAL DISTRIBUTION OF L/D RATIOS

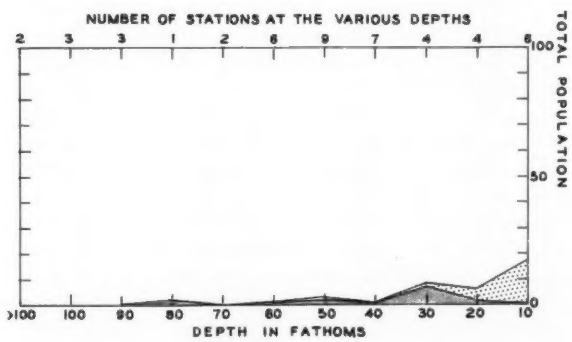


TEXT-FIGURE 11

AREAL DISTRIBUTION OF NUMBERS OF FORAMINIFERA PER GRAM OF SEDIMENT



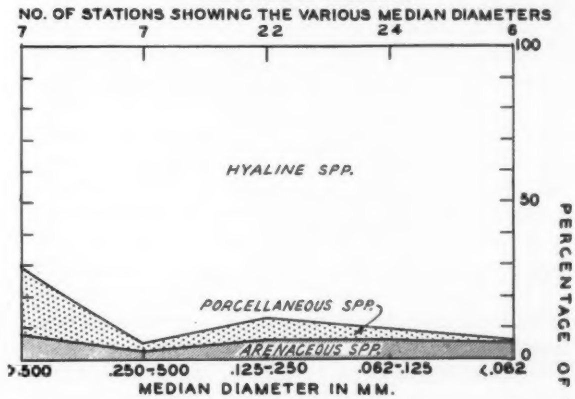
TEXT-FIGURE 12a



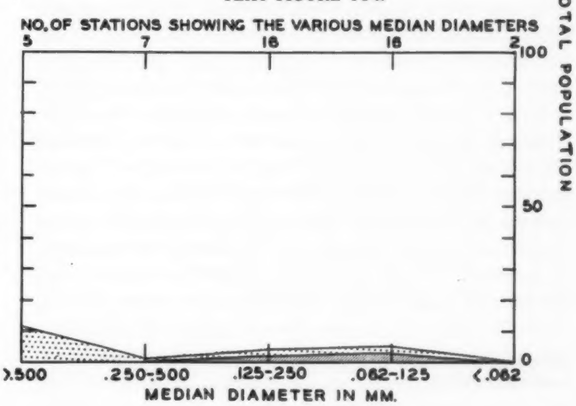
TEXT-FIGURE 12b

TEXT-FIGURE 12

Composite frequency diagrams showing effect of depth upon the three types of foraminiferal tests: a, tests of dead specimens; b, tests of living specimens.



TEXT-FIGURE 13a



TEXT-FIGURE 13b

TEXT-FIGURE 13

Composite frequency diagrams showing effect of grain size upon distribution of the three types of foraminiferal tests: a, tests of dead specimens; b, tests of living specimens.

100–200 feet, 10.6–15.4° C., salinity 33.3–33.9 parts per thousand, oxygen 3.1–6.4 milliliters per liter.
Rotorbinella versiformis
Cassidulina californica
Cassidulina limbata
(Note: *Cassidulina* less than 30%)
Cassidulina quadrata
Cassidulina tortuosa
Nonionella miocenica var. *stella*
Buccella frigida
Trochammina pacifica
Cibicides fletcheri

Lower neritic zone — 200–800 feet, 8.8–13.6° C., salinity 33.6–34.2 parts per thousand, oxygen 1.8–4.7 milliliters per liter.

(150–800 feet) *Cassidulina californica*
Cassidulina limbata
Cassidulina quadrata
(Note: *Cassidulina* greater than 30%)
Cassidulina tortuosa
Angulogerina angulosa
Bolivina advena var. *acutula*
Bolivina acuminata
Bolivina pacifica
Bulimina denudata

The deeper zonation is not included.

On the whole, the distribution of species around Santa Catalina Island agrees with Bandy's zonation except for the species in the 40 to 100-foot zone, which were found to be rare in the Catalina samples. It is interesting to note that Bandy stated that species of *Cassidulina* comprise less than 30 per cent of the benthonic population at depths of 200 feet and less, and more than 30 per cent at depths greater than 200 feet. This is closely comparable with the abundance of species of *Cassidulina* around Santa Catalina Island. Bandy also found that species of *Uvigerina* can be used as depth indicators. Delicately costate species of *Uvigerina*, such as *Uvigerina hollicki*, were found to be representative of the lower neritic zone. *Uvigerina hollicki* is rare in the Catalina samples, but does occur in the appropriate depth range.

FACTORS AFFECTING THE DISTRIBUTION OF BENTHONIC FORAMINIFERA

Both chemical and physical factors may affect the distribution of foraminifera. These factors can be measured directly and utilized to explain distributional patterns of living species. If the distribution of dead specimens is comparable with that of the living species, then these factors can also be applied to former conditions.

TABLE 6

RATIOS OF LIVING TO DEAD SPECIMENS

Station number	*Living*	*Dead*	*Ratio*
3569	...	...	0
3570	219	29,504	7.4
3571	5	87	57.5
3572	35	47,360	0.7
3573	636	148,992	4.3
3574	161	17,152	9.4
3575	...	...	0
3576	...	...	0
3577	...	...	0
3578	...	...	0
3579	20	31,680	0.6
3580	18	14,144	1.3
3581	71	11,264	6.3
3582	...	...	...
3583	...	...	...
3584	...	...	...
3585	...	...	...
3586	...	...	...
3587	153	6592	23.2
3588	432	3680	117.4
3591	176	595,968	0.3
3592	736	232,448	3.2
3593	1520	290,816	5.2
3595	3	4752	0.6
3596	6	140,544	0.1
3597	448	27,328	16.4
3598	3	2600	1.2
3599	6	20,064	0.3
3600	114	9920	11.5
3601	186	9536	19.5
3602	5	4592	1.1
3603	...	...	0
3604	...	...	0
3605	...	...	0
3606	...	...	0
3607	...	...	0
3608	712	17,408	40.9
3609	864	10,256	84.2
3610	792	2920	271.2
3611	55	6032	9.1
3612	63	41,216	1.5
3613	320	109,568	2.9
3614	32	72,448	0.4
3615	21	129,024	0.2
3616	9	170,496	0.1
3617	20	249,856	0.1
3618	65	119,808	0.5
3971	...	...	0
3973	...	...	0
3974	2	141,824	0.1
3975	672	36,214	18.6
3976	272	95,744	2.8
3977	368	37,760	9.7

TABLE 6 (*continued*)

RATIOS OF LIVING TO DEAD SPECIMENS

Station number	*Living*	*Dead*	*Ratio*
3978	236	8576	27.5
3979	160	249,815	0.6
3980	240	253,952	0.9
3981	130	57,088	2.3
3982	43	7680	5.6
3983	44	24,246	1.8
3984	64	39,552	1.6
3985	27	16,096	1.7
3987	2	131	15.3
3988	37	257	143.9
3989	...	...	0
3990	...	...	0
3991	204	3840	53.1
3993	416	4168	99.8
3994	39	344	113.4
3995	...	...	0
3996	...	...	0
3997	...	...	0

The following discussion considers each of the factors that might be essential in foraminiferal distribution, although not necessarily in order of their importance.

Sediments

The bathymetric differentiation of dead specimens in three depth ranges, 0 to 20 fathoms, 21 to 40 fathoms, and 41 to greater than 100 fathoms, holds true for most of the offshore profiles surrounding the island, with the exception of Profile 4 (text-fig. 14). That profile (stations 3581 to 3588) extends from a depth of 4 feet to 100 fathoms, and grades from gravelly sand and fine-grained sand at the head of Catalina Harbor to silt at approximately 100 fathoms. This sedimentary gradation is unusual in that it does not occur in the other profiles. It is not surprising that a different type of foraminiferal fauna is present. The shallow-water assemblage is essentially the same, but there is a distinct change in the character of the deeper-water assemblages (50 to 100 fathoms). *Cancris sagra*, *Bolivina acuminata*, and *Bolivina pacifica*, which do not ordinarily characterize any particular depth range, occur in large percentages. *Bulimina auriculata*, which rarely occurs in the other samples surrounding the island, is relatively abundant. *Uvigerina hollicki*, a deeper-water foraminifer, is present in depths exceeding 60 fathoms. The most striking incongruity, however, is the fact that species of *Cassidulina* make up far less than their usual percentage of the benthonic foraminifera. This difference can be accounted for by the absence of *Cassidulina tortuosa*, even in depths greater than 50 fathoms. The conditions necessary for the deposition of fine-grained sediments must certainly exert an influence upon the type of foraminiferal assemblage present.

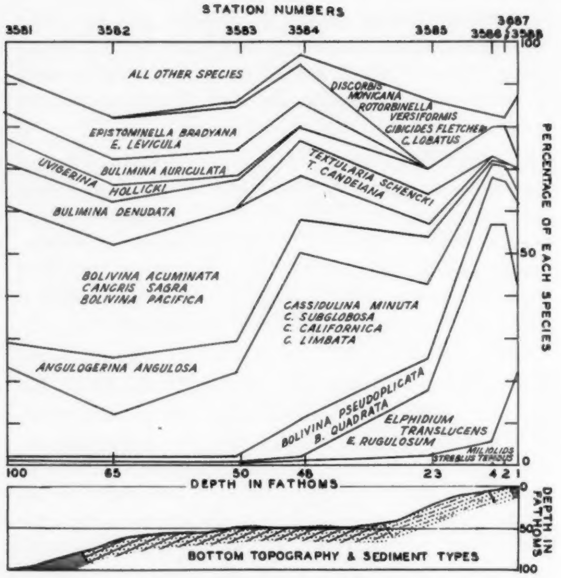
The effect of the type of sediment upon the living species in Profile 4 is uncertain because no living specimens were found in the depth range from approximately 2 fathoms to 100 fathoms. However, the species found living in very shallow water (less than 2 fathoms) and in deep water (approximately 100 fathoms) agree with the bathymetric distribution.

The effect, if any, that the median diameter of the sediment exerts upon the distribution of living foraminifera is illustrated in text-figure 15. Although no single species is limited to sediments of any particular grain size, some species exhibit a tendency to be more abundant in sediments of either one or several grain sizes. For example, *Rotorbinella versiformis* and *Buliminella elegantissima* are more common in sediments with median diameters greater than 0.500 mm., whereas *Bulimina denudata* and *Bolivina acuminata* are common in sediments with median diameters less than 0.125 mm. Conversely, species such as *Cassidulina minuta*, *Cancris sagra*, *Bolivina pacifica*, *Bolivina quadrata*, and *Angulogerina angulosa* are almost equally abundant in sediments of all grain sizes.

Submarine topography

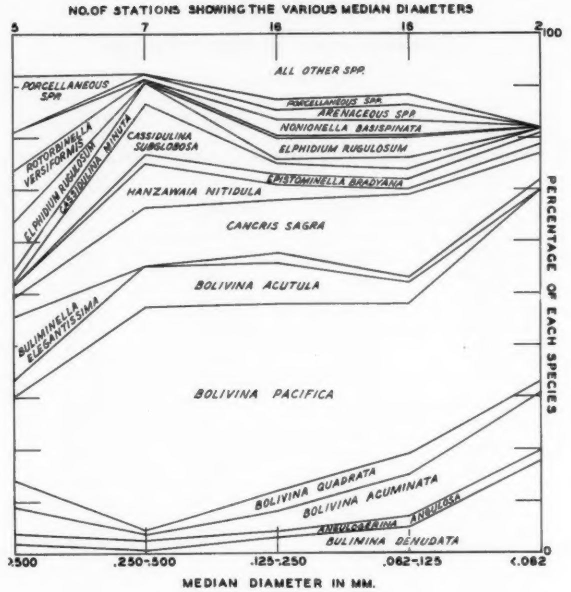
Farnsworth Bank, which is approximately 1½ miles from shore, is located in Profile 5 (station 3595). From a brief examination of text-figure 16 it is apparent that the distributional patterns of the dead foraminifera are interrupted by the bank. Species of miliolids, which are very abundant in shallow water, make up 30 per cent of the foraminiferal population. *Discorbis monicana*, a typical shallow-water foraminifer, also occurs in considerable percentage, along with two species that are rare in other Santa Catalina Island samples, *Poroeponides cribrorepandus* and *Cibicides gallowayi*. Species of *Cassidulina* become very abundant in depths of about 30 fathoms, but, as the bank is approached, they decrease very rapidly in percentage. *Cassidulina tortuosa* and *Cassidulina subglobosa* make up the majority of the species of *Cassidulina* in the areas surrounding the bank.

The distribution of the living species in Profile 5 also shows the effect of the offshore bank (text-fig. 17). Shallow-water species, species of miliolids, and *Textularia schencki* make up the total benthonic



TEXT-FIGURE 14

FREQUENCY DIAGRAM OF DEAD SPECIMENS IN THE PROFILE EXTENDING OUT FROM CATALINA HARBOR (PROFILE 4)



TEXT-FIGURE 15

COMPOSITE FREQUENCY DIAGRAM SHOWING THE EFFECT OF MEDIAN DIAMETER OF SEDIMENT UPON THE DISTRIBUTION OF LIVING FORAMINIFERA

population on the bank. These species were also found in the dead population. Otherwise, the resemblance between the living and dead populations in the profile is negligible. It is interesting to note that a very large bryozoan population is found on the bank.

Changes in sea level

A change in sea level explains the difference between the depth ranges of the living and dead species. In many instances, the living representatives of a given species are found in a more restricted depth range than the dead individuals of the same species. Living species of miliolids and *Elphidium rugulosum* are primarily restricted to 20 fathoms and less, whereas in the dead population (see text-figs. 8 and 9) they are abundant in depths of at least 30 fathoms. Also, *Rotorbinella versiformis*, which is present in the dead assemblages of the entire shelf and slope, although in relatively low percentages, is restricted to depths of approximately 35 fathoms and less in the living population. Because some living species are restricted to shallower depths than those of their dead representatives, it is believed that a transgression of the sea or a subsidence of the island may have occurred.

A change in sea level may be responsible for the zone of broken foraminiferal tests, especially those of *Cassidulina tortuosa*, that occurs on the outer shelf and slope surrounding the island. Other species represented by broken tests, although in minor amounts, are *Cassidulina limbata*, *Cassidulina californica*, *Cibicides fletcheri*, *Cibicides mckannai*, *Cibicides refulgens*, and *Elphidium fax fax*. In some samples the tests of 80 per cent of the total benthonic population are broken.

There are three possible explanations of this phenomenon, two of which do not entail a change in sea level:

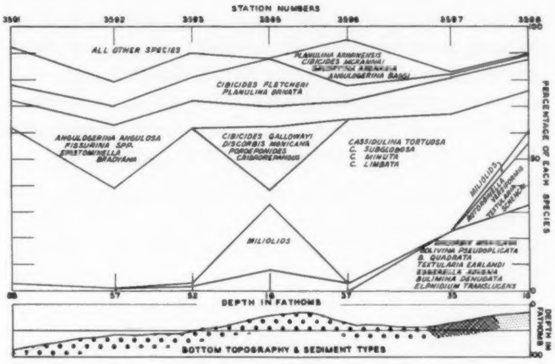
1) Natland (1933) postulated that the tests had been lying uncovered on the sea bottom for a long period of time, thereby accounting for their badly worn and broken condition. This condition could be true of the area surrounding Santa Catalina Island, where the rate of sedimentation is slow.

2) Current action may have a considerable effect upon the condition of foraminiferal tests.

3) The zone of broken tests may indicate a former shoreline, where foraminiferal tests would have been subjected to constant wave action.

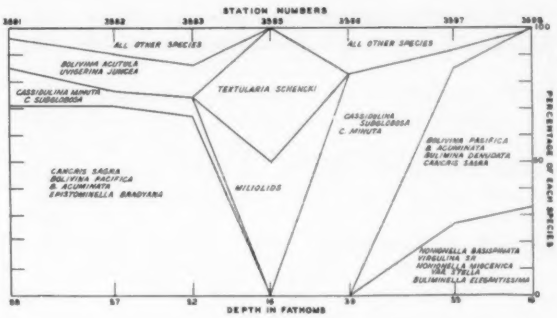
Salinity

The salinity of the sea water, which is probably uniform around Santa Catalina, has small annual



TEXT-FIGURE 16

FREQUENCY DIAGRAM OF DEAD SPECIMENS IN THE PROFILE EXTENDING ACROSS FARNSWORTH BANK (PROFILE 5)



TEXT-FIGURE 17

FREQUENCY DIAGRAM OF LIVING SPECIMENS IN THE PROFILE EXTENDING ACROSS FARNSWORTH BANK (PROFILE 5)

variation, and therefore does not appear to exert any influence upon foraminiferal distribution. *Streblus tepidus*, however, is present in the dead population and has been recorded from San Francisco Bay, which has a salinity variation of 20 to 30 parts per thousand (Bandy, 1953), and from other brackish-water environments. It occurs in very shallow water (stations 3586 and 3587) near the head of Catalina Harbor, which may have been more completely enclosed at one time, as well as being a site of greater runoff from the adjacent land; it also occurs at station 3978, on the leeward side of the island, in 22 fathoms depth.

Temperature

Temperature may be a very important factor in the distribution of foraminifera because of its high annual variation in very shallow depths, as well as because of its decrease with increasing depth. However, it is difficult to ascertain whether temperature alone is a limiting factor, or whether depth plays an equally important role.

Certain living species of miliolids, *Quinqueloculina poeyana* and *Quinqueloculina laevigata*, are restricted to very shallow water (approximately 10 fathoms and less), and must therefore be capable of tolerating the large annual temperature variation of approximately 5 to 7°. They apparently are not tolerant of cooler temperatures, and are therefore absent in deeper water. Other species, which occur not only in the 0-to-20-fathoms depth range but also in greater depths, can survive a large annual variation as well as lower temperatures. Species restricted to depths greater than 30 fathoms can endure lower temperatures, but can not tolerate the large annual variation characteristic of shallow water.

Hoeglundina elegans, which has been reported from depths greater than 490 fathoms by Walton (1955) and greater than 1000 fathoms by Bandy (1953), was found in excellent preservation but not living, in depths of 50 fathoms and greater. In addition, *Ehrenbergina compressa*, which was found living in depths not less than 260 fathoms by Walton (1955), occurs as dead specimens at a depth of 44 fathoms and living at 103 fathoms. Evidently, these two species have a far greater depth range than has previously been recorded, as well as a greater tolerance toward temperature changes.

Depth

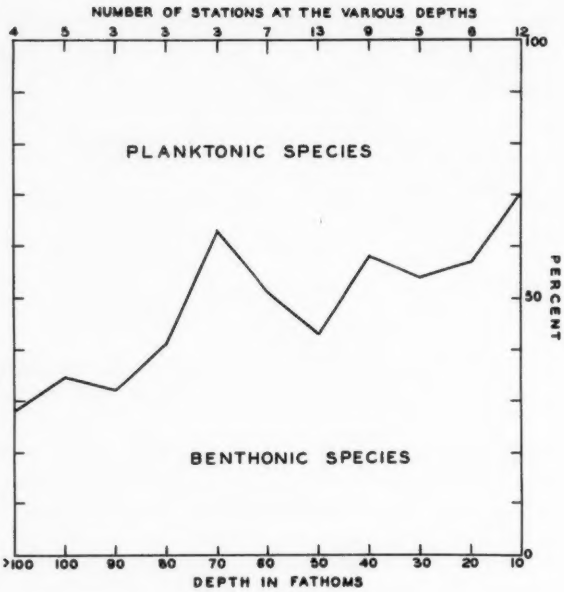
The bathymetric distribution of foraminifera has been discussed in detail in a previous section. It is difficult to determine whether depth is the predominant influence in foraminiferal distribution, or whether other associated factors, such as temperature, salinity, oxygen, and perhaps sedimentary types, are more or equally important.

Oxygen

Oxygen measurements are included in order to make the description of the Santa Catalina environment as complete as possible. An excess of oxygen may be expected to occur in very shallow water, where wave action is predominant, and may restrict the distribution of some species of foraminifera. Oxygen may also be a factor in foraminiferal distribution when it is at a minimum, as in closed basins or at great depths.

DISTRIBUTION OF PLANKTONIC FORMS

The distribution of planktonic foraminifera is dependent upon two factors, currents and abundance of nutrients. Other factors, which are important in the distribution of benthonic foraminifera, are



TEXT-FIGURE 18

COMPOSITE FREQUENCY DIAGRAM SHOWING THE RELATIONSHIP BETWEEN PLANKTONIC AND BENTHONIC SPECIES

either unimportant or invalid in connection with planktonic forms. Current action is mainly responsible for wide planktonic distribution, and upwelling, which causes an increase in nutrients, is an important factor in increasing planktonic abundance in smaller areas. The latter factor can be assumed in restricted areas around Santa Catalina Island, especially off the northwestern end, where upwelling is known to occur.

In general, the percentage of planktonic forms that make up the foraminiferal population increases with increasing distance from shore (text-fig. 18). In nearshore areas, benthonic species make up the larger percentage, especially in areas partly protected from currents. A prime example is represented by the three stations (3586–3588) located near the head of Catalina Harbor, where benthonic foraminifera make up more than 90 per cent of the total population.

Species of *Globigerina* have not been differentiated, because of their unimportance in this study. Other planktonic species present are *Globorotalia puncticulata*, *Globorotalia truncatulinoides*, and *Orbulina universa*.

SUMMARY AND CONCLUSIONS

Because the distribution of species is the same on both sides of Santa Catalina Island, the living and dead foraminiferal populations can be divided into three distinct depth zones, or biofacies, ranging from 0 to 20 fathoms, from 21 to 40 fathoms, and from 41 to greater than 100 fathoms. Very few similarities exist between the living and dead assemblages, with the exception of some shallow-water species.

Not only can a depth zonation be made for the living foraminifera, but oceanographic characteristics can be included as well, in order to establish present ecological conditions:

0 to 20 fathoms:

Fauna: *Elphidium rugulosum*, *Nonionella basispinata*, *Textularia articulata*, *Quinqueloculina poeyana*, species of miliolids, *Rotorbinella versiformis*, *Bolivina quadrata*, and *Buliminella elegantissima*.
Temperature: 11.1–20.6° C.
Salinity: 33.3–33.7 parts per thousand.
Oxygen: 4.7–6.2 milliliters per liter.

21 to 40 fathoms:

Fauna: *Bolivina quadrata*, *Nonionella basispinata*, *Bolivina compacta*, *Buliminella elegantissima*, *Rotorbinella versiformis*, species of miliolids, and *Elphidium rugulosum*.
Temperature: 9.6–14.2° C.
Salinity: 33.3–33.8 parts per thousand.
Oxygen: 3.0–6.0 milliliters per liter.

41 to greater than 100 fathoms:

Fauna: *Bolivina pacifica*, *Cancris sagra*, *Hanzawaia nitidula*, *Bolivina acuminata*, *Bolivina tongi*, and *Angulogerina angulosa*.
Temperature: 8.0–11.1° C.
Salinity: 33.5–34.1 parts per thousand.
Oxygen: 1.6–4.7 milliliters per liter.

Temperature or depth, or a combination of both, is the factor most responsible for the distribution of the various species of foraminifera around Santa Catalina Island. Salinity and oxygen are of minor importance. However, other factors, including submarine topography and sedimentation, influence foraminiferal distribution in small areas. An example of the influence of submarine topography is Farnsworth Bank, which is inhabited by a typical shallow-water fauna even though it is more than 1½ miles from shore and is separated from the coast by greater depths. On the other hand, sedimentation appears to have affected the distribution of certain species, especially those of *Cassidulina*, in the area extending out from Catalina Harbor.

Another factor which is important in the distribution of foraminifera, but only over a comparatively long

period of time, is changes in sea level. The author believes that this factor offers the best explanation for the differences observed between the depth ranges of living and dead specimens of the same species.

Other conclusions drawn from this study are:

1) The relative rate of sedimentation is best shown by determining the number of foraminifera per gram of sediment. Ratios between living and dead specimens are not always practicable, because they are dependent upon the existence of living species.

2) Species of miliolids, if they occur in great abundance, are good indicators of very shallow water.

3) The median diameter of the sediment does not exert a great influence upon foraminiferal distribution.

4) Calcium carbonate content of the sediment is directly proportional to the number of foraminifera present.

5) The slow rate of sedimentation indicated by the large number of foraminifera per gram of sediment and the high L/D ratios is due to the limited source of sediment. Whereas the shallow shelf area of the adjacent mainland derives much of its sediment from streams, erosion of the island coastline serves as the principal source of sediment for the Santa Catalina shelf and slope.

FAUNAL REFERENCE LIST

The original reference is given below for each species mentioned in the frequency profiles, as well as for those listed in the faunal charts (Tables 7 and 8), with the exception of foraminifera not identified as to species.

Angulogerina angulosa (Williamson) = *Uvigerina angulosa* Williamson, 1858, Recent Foram. Gt. Britain, p. 67, pl. 5, fig. 140.

Angulogerina baggi (Galloway and Wissler) = *Uvigerina baggi* Galloway and Wissler, 1927, Jour. Pal., vol. 1, p. 75, pl. 11, fig. 19.

Angulogerina carinata Cushman, 1927, Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 1, p. 159, pl. 4, fig. 3.

Bolivina acuminata Natland, 1946, in Cushman and Gray, Cushman Lab. Foram. Res., Spec. Publ. no. 19, p. 34, pl. 5, fig. 46.

Bolivina advena Cushman var. *acutula* Bandy, 1953, Jour. Pal., vol. 27, p. 180, pl. 24, fig. 7.

Bolivina argentea Cushman var. *monicana* Zalesny, 1959, Micropaleontology, vol. 5, no. 1, p. 123, pl. 1, fig. 1a–b.

Bolivina compacta Sidebottom = *Bolivina robusta* Brady var. *compacta* Sidebottom, 1905, Manchester Lit. Philos. Soc., Mem. Proc., vol. 49, no. 5, p. 15, pl. 3, fig. 7.

Bolivina pacifica Cushman and McCulloch, 1942, Allan Hancock Pacific Exped., vol. 6, no. 4, p. 185, pl. 21, figs. 2–3.

Bolivina pseudoplicata Heron-Allen and Earland, 1930, Roy. Micr. Soc. London, Jour., ser. 3, vol. 50, pt. 1, p. 81, pl. 3, figs. 36–40.

Bolivina quadrata Cushman and McCulloch, 1942, Allan Hancock Pacific Exped., vol. 6, no. 4, p. 205, pl. 25, fig. 13.

Bolivina tongi Cushman, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, p. 93, pl. 13, fig. 29.

Bulimina auriculata Bailey, 1851, Smithsonian Inst., Contr. Knowledge, vol. 2, art. 3, p. 12, pl., figs. 25–27.

Bulimina denudata Cushman and Parker, 1938, Cushman Lab. Foram. Res., Contr., vol. 14, p. 57, pl. 10, figs. 1–2.

Bulimina elongata d'Orbigny var. *subulata* Cushman and Parker, 1937, ibid., vol. 13, p. 51, pl. 7, figs. 6–7.

Buliminella elegantissima (d'Orbigny) = *Bulimina elegantissima* d'Orbigny, 1839, Voy. Amér. Mérid., vol. 5, pt. 5, Foraminifères, p. 51, pl. 7, figs. 13–14.

Cancris sagra (d'Orbigny) = *Rotalina (Rotalina) sagra* d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 77, pl. 5, figs. 13–15.

Cassidulina californica Cushman and Hughes, 1925, Cushman Lab. Foram. Res., Contr., vol. 1, p. 12, pl. 2, fig. 1.

Cassidulina caribeana Redmond, 1953, Jour. Pal., vol. 27, p. 729, pl. 77, fig. 6.

Cassidulina delicata Cushman, 1927, Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 1, p. 168, pl. 6, fig. 5.

Cassidulina limbata Cushman and Hughes, 1925, Cushman Lab. Foram. Res., Contr., vol. 1, p. 12, pl. 2, fig. 2.

Cassidulina minuta Cushman, 1933, ibid., vol. 9, p. 92, pl. 10, fig. 3.

Cassidulina subglobosa H. B. Brady, 1881, Quart. Jour. Micr. Sci., new ser., vol. 21, p. 60.

Cassidulina subglobosa H. B. Brady var. *quadrata* Cushman and Hughes, 1925, Cushman Lab. Foram. Res., Contr., vol. 1, p. 15, pl. 2, fig. 7. (Specimens of this species were combined with the preceding species in the frequency counts.)

Cassidulina tortuosa Cushman and Hughes, 1925, ibid., vol. 1, p. 14, pl. 2, fig. 4.

Chilostomella czjzeki Reuss, 1850, K. Akad. Wiss. Wien, Denkschr., vol. 1, p. 380, pl. 48, fig. 13.

Cibicides fletcheri Galloway and Wissler, 1927, Jour. Pal., vol. 1, p. 64, pl. 10, figs. 8–9.

Cibicides gallowayi Cushman and Valentine, 1930, Stanford Univ., Dept. Geol., Contr., vol. 1, no. 1, p. 30, pl. 10, fig. 4.

Cibicides lobatus (d'Orbigny) [(Montagu)] = *Truncatulina lobata* [(Montagu)] d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, Foraminifères, p. 134, pl. 2, figs. 22–24 [= *Serpula lobata* Montagu, 1803].

Cibicides mckannai Galloway and Wissler, 1927, Jour. Pal., vol. 1, p. 65, pl. 10, figs. 5–6.

Cibicides refulgens Montfort, 1808, Conch. Syst., vol. 1, p. 123, text-figs.

Discorbis lauriei (Heron-Allen and Earland) = *Discorbina lauriei* Heron-Allen and Earland, 1924, Linnean Soc. London, Jour., Zool., vol. 35, p. 633, pl. 36, figs. 50–52; pl. 37, figs. 53–55.

Discorbis monicana Zalesny, 1959, Micropaleontology, vol. 5, no. 1, p. 124, pl. 1, fig. 4a–c.

Dvocibicides biserialis Cushman and Valentine, 1930, Stanford Univ., Dept. Geol., Contr., vol. 1, no. 1, p. 31, pl. 10, figs. 1–2.

Eggerella advena (Cushman) = *Verneuilina advena* Cushman, 1922, Contr. Canadian Biol., no. 9, p. 141.

Ehrenbergina compressa Cushman, 1927, Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 1, p. 168, pl. 6, fig. 7.

Elphidium articulatum (d'Orbigny) = *Polystomella articulata* d'Orbigny, 1839, Voy. Amér. Mérid., vol. 5, pt. 5, Foraminifères, p. 30, pl. 3, figs. 9–10.

Elphidium fax Nicol subsp. *fax* Nicol, 1944, Jour. Pal., vol. 18, p. 177.

Elphidium rugulosum Cushman and Wickenden, 1929, U. S. Nat. Mus., Proc., vol. 75, art. 9 (no. 2780), p. 7, pl. 3, fig. 8.

Elphidium translucens Natland, 1938, Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 4, p. 144, pl. 5, figs. 3–4.

Elphidium tumidum Natland, 1938, ibid., vol. 4, p. 144, pl. 5, figs. 5–6. (Specimens of this species were included in the frequency count of the preceding species.)

Epistominella bradyana (Cushman) = *Pulvinulinella bradyana* Cushman, 1927, Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 1, p. 165, pl. 5, figs. 11–13.

Epistominella levicula Resig, 1958, Micropaleontology, vol. 4, no. 3, p. 304, tf. 16a–c.

Gaudryina arenaria Galloway and Wissler, 1927, Jour. Pal., vol. 1, p. 68, pl. 11, fig. 5.

Gaudryina atlantica (Bailey) var. *pacifica* Cushman and McCulloch, 1939, Allan Hancock Pacific Exped., vol. 6, no. 1, p. 94, pl. 9, figs. 1–2.

Gaudryina subglabrata Cushman and McCulloch, 1939, ibid., vol. 6, no. 1, p. 92, pl. 8, figs. 5–7.

Globorotalia puncticulata (d'Orbigny) = *Globigerina puncticulata* d'Orbigny, 1832, in Deshayes, Ency. Méth., vol. 2, pt. 2, p. 170.

Globorotalia truncatulinoides (d'Orbigny) = *Rotalina truncatulinoides* d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, p. 132, pl. 2, figs. 25–27.

Goesella flintii Cushman, 1936, Cushman Lab. Foram. Res., Spec. Publ. no. 6, p. 34, pl. 5, fig. 8.

Guttulina quinquecosta Cushman and Ozawa, 1930, in Cushman and Valentine, Stanford Univ., Dept. Geol., Contr., vol. 1, no. 1, p. 19, pl. 5, fig. 6.

Hanzawaia basiloba (Cushman) var. *nitidula* (Bandy) = *Cibicidina basiloba* (Cushman) var. *nitidula* Bandy, 1953, Jour. Pal., vol. 27, p. 178, pl. 22, fig. 3.

Haplophragmoides advena Cushman, 1925, Cushman Lab. Foram. Res., Contr., vol. 1, p. 38, pl. 6, fig. 1.

Haplophragmoides columbiensis Cushman var. *evolutus* Cushman and McCulloch, 1939, Allan Hancock Pacific Exped., vol. 6, no. 1, p. 73, pl. 5, figs. 11–12; pl. 6, figs. 1–2.

Hoeglundina elegans (d'Orbigny) = *Rotalia (Turbinuline) elegans* d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 276.

Hopkinsina pacifica Cushman, 1933, Cushman Lab. Foram. Res., Contr., vol. 9, p. 86, pl. 8, fig. 16.

Involutina pacifica (Cushman and Valentine) = *Ammodiscus pacificus* Cushman and Valentine, 1930, Stanford Univ., Dept. Geol., Contr., vol. 1, no. 1, p. 7, pl. 1, fig. 1.

Nonionella basiloba Cushman and McCulloch, 1940, Allan Hancock Pacific Exped., vol. 6, no. 3, p. 162, pl. 18, fig. 3.

Nonionella basispinata (Cushman and Moyer) = *Nonion pizarrensis* Berry var. *basispinata* Cushman and Moyer, 1930, Cushman Lab. Foram. Res., Contr., vol. 6, p. 54, pl. 7, fig. 18.

Nonionella miocenica Cushman var. *stella* Cushman and Moyer, 1930, ibid., vol. 6, p. 56, pl. 7, fig. 17.

Orbulina universa d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 3, pl. 1, fig. 1.

Patellina corrugata Williamson, 1858, Recent Foram. Gt. Britain, p. 46, pl. 3, figs. 86–89.

Planorbulina mediterranensis d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 280, pl. 14, figs. 4–6.

Planulina ariminensis d'Orbigny, 1826, ibid., ser. 1, vol. 7, p. 280, pl. 14, figs. 1–3; Modèle no. 49.

Planulina ornata (d'Orbigny) = *Truncatulina ornata* d'Orbigny, 1839, Voy. Amér. Mérid., vol. 5, pt. 5, Foraminifères, p. 40, pl. 6, figs. 7–9.

Poroeponides cribrorepandus Asano and Uchio, 1951, in Asano, Illust. catalogue of Japanese Tertiary smaller foraminifera, pt. 14, p. 18, text-figs. 134–135.

Proteonina atlantica Cushman, 1944, Cushman Lab. Foram. Res., Spec. Publ. no. 12, p. 5, pl. 1, fig. 4.

Proteonina grzybowskii (Schubert) = *Reophax grzybowskii* Schubert, 1901, Beitr. Pal. Geol. Österreich-Ungarns Orients, vol. 14, no. 1–2, p. 20, pl. 1, fig. 13.

Pullenia salisburyi R. E. Stewart and K. C. Stewart, 1930, Jour. Pal., vol. 4, p. 72, pl. 8, fig. 2.

Pyrgo oblonga (d'Orbigny) = *Biloculina oblonga* d'Orbigny 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 163, pl. 8, figs. 21–23.

Quinqueloculina bidentata d'Orbigny, 1839, ibid., pp. 197–198, pl. 12, figs. 18–20.

Quinqueloculina catalinensis Natland, 1938, Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 4, p. 142, pl. 4, fig. 3.

Quinqueloculina elongata Natland, 1938, ibid., vol. 4, pp. 141–142, pl. 4, fig. 5a–c.

Quinqueloculina flexuosa d'Orbigny, 1839, Voy. Amér. Mérid., vol. 5, pt. 5, Foraminifères, p. 73, pl. 4, figs. 4–6.

Quinqueloculina gigas Natland, 1938, Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 4, p. 141, pl. 4, fig. 4.

Quinqueloculina jugosa Cushman, 1944, Cushman Lab. Foram. Res., Spec. Publ. no. 12, p. 13, pl. 2, fig. 15.

Quinqueloculina laevigata d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, p. 143, pl. 3, figs. 31–33.

Quinqueloculina lamarckiana d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 189, pl. 11, figs. 14–15.

Quinqueloculina poeyana d'Orbigny, 1839, ibid., p. 191, pl. 11, figs. 25–27.

Quinqueloculina sabulosa Cushman, 1947, Cushman Lab. Foram. Res., Contr., vol. 23, p. 87, pl. 18, fig. 22.

Recurvoides contortus Earland, 1934, Discovery Repts., vol. 10, p. 91, pl. 3, figs. 11–12.

Reophax excentricus Cushman, 1910, U. S. Nat. Mus., Bull. 71, pt. 1, pp. 92–93, tf. 134.

Reophax scorpiurus Montfort, 1808, Conch. Syst., vol. 1, p. 330, text-figs.

Robertina charlottensis (Cushman) = *Cassidulina charlottensis* Cushman, 1925, Cushman Lab. Foram. Res., Contr., vol. 1, p. 41, pl. 6, figs. 6–7.

Robulus cultratus Montfort, 1808, Conch. Syst., vol. 1, pp. 215, 216; p. 214, text-figs.

Rotorbinella lomaensis (Bandy) = *Rotalia lomaensis* Bandy, 1953, Jour. Pal., vol. 27, p. 179, pl. 22, fig. 6.

Rotorbinella turbinata (Cushman and Valentine) = *Rotalia turbinata* Cushman and Valentine, Stanford Univ., Dept. Geol., Contr., vol. 1, no. 1, p. 25, pl. 7, figs. 1, 3.

Rotorbinella versiformis (Bandy) = *Rotalia versiformis* Bandy, 1953, Jour. Pal., vol. 27, p. 179, pl. 22, fig. 5.

Rupertia stabilis Wallich, 1877, Ann. Mag. Nat. Hist., ser. 4, vol. 19, p. 301, pl. 20, figs. 1–13.

Sigmoilina tenuis (Czjzek) = *Quinqueloculina tenuis* Czjzek, 1848, Haid. Nat. Abh., vol. 2, pt. 1, p. 149, pl. 13, figs. 31–34.

Spiroloculina depressa d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 298.

Streblus tepidus (Cushman) = *Rotalia beccarii* (Linné) var. *tepida* Cushman, 1926, Carnegie Inst. Washington, Publ. no. 344, p. 79, pl. 1, figs. (This species has been identified as *Rotalia beccarii* (Linné) by other authors.)

Textularia articulata d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 250, pl. 15, figs. 16–18.

Textularia candeiana d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 143, pl. 1, figs. 25–27.

Textularia earlandi Parker, 1952, Harvard Coll., Mus. Comp. Zoöl., Bull., vol. 106, no. 10, p. 458 (footnote).

Textularia schencki Cushman and Valentine, 1930, Stanford Univ., Dept. Geol., Contr., vol. 1, no. 1, p. 8, pl. 1, fig. 3.

Triloculina laevigata d'Orbigny, 1878, in Terquem, Soc. Geol. France, Mém., ser. 3, vol. 1, no. 3, p. 57, pl. 5, figs. 20–21 [homonym of *Triloculina laevigata* Bornemann, 1855].

Triloculina rotunda d'Orbigny, 1893, in Schlumberger. Soc. Zool. France, Mém., vol. 6, p. 64, pl. 1, figs, 48–50; text-figs. 11–12.

Triloculina trigonula (Lamarck) = *Miliolites trigonula* Lamarck, 1804, Paris, Mus. National Hist. Nat., Ann., vol. 5, p. 351; 1807, ibid., vol. 9, pl. 17, fig. 4.

Trochammina pacifica Cushman, 1925, Cushman Lab. Foram. Res., Contr., vol. 1, p. 39, pl. 6, fig. 3.

Trochammina squamiformis Cushman and McCulloch, 1939, Allan Hancock Pacific Exped., vol. 6, no. 1, p. 108, p. 12, fig. 4.

Uvigerina hollicki Thalman, 1950, Cushman Found. Foram. Res., Contr., vol. 1, pts. 3–4, p. 45.

Uvigerina juncea Cushman and Todd, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, p. 78, pl. 20, figs. 4–11.

Virgulina schreibersiana Czjzek, 1848, Haid. Nat. Abh., vol. 2, pt. 1, p. 147, pl. 13, figs. 18–21.

BIBLIOGRAPHY

Bandy, O. L.

1953 – *Ecology and paleoecology of some California foraminifera; Part I – The frequency distribution of Recent foraminifera off California.* Jour. Pal., vol. 27, no. 2, pp. 161–182, pls. 21–25, text-figs. 1–4, table 1.

1954 – *Distribution of some shallow-water foraminifera in the Gulf of Mexico.* U. S. Geol. Survey, Prof. Paper no. 254-F, pp. 125–141, pls. 28–31, text-figs. 5–13.

Butcher, W. S.

1951 – *Foraminifera, Coronado Bank and vicinity, California.* Scripps Inst. Oceanogr., Submarine Geol. Rept. no. 19, pp. i–iii, 1–9, text-figs. 1–6.

Church, C. C.

1929 – *Some Recent shallow-water foraminifera dredged near Santa Catalina Island, California.* Jour. Pal., vol. 3, no. 3, pp. 302–305.

Clements, T.

1949 – *Terraces on Santa Catalina Island.* Geol. Soc. Amer., Bull., vol. 59, p. 1368 (abstract).

1955 – *The Pleistocene history of the Channel Island region, southern California.* In: *Essays in the Natural Sciences in Honor of Captain Allan Hancock.* Los Angeles: University of Southern California Press, pp. 311–323.

Crouch, R. W.

1952 – *Significance of temperature on foraminifera from deep basins off southern California coast.* Amer. Assoc. Petrol. Geol., Bull., vol. 36, no. 5, pp. 807–843, pls. 1–7, text-figs. 1–5.

Cushman, J. A.

1927 – *Recent foraminifera from off the west coast of America.* Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 1, pp. 119–188, pls. 1–6.

Cushman, J. A., and Gray, H. B.

1946 – *A foraminiferal fauna from the Pliocene of Timms Point, California.* Cushman Lab. Foram. Res., Spec. Publ. no. 19, pp. 1–46, pls. 1–8.

Cushman, J. A., and McCulloch, I.

1939 – *A report on some arenaceous foraminifera.* Allan Hancock Pacific Exped., vol. 6, no. 1, pp. 1–113, pls. 1–12.

1940 – *Some Nonionidae in the collections of the Allan Hancock Foundation.* Ibid., vol. 6, no. 3, pp. 145–178, pls. 17–20, tables 6–8.

1942 – *Some Virgulininae in the collections of the Allan Hancock Foundation.* Ibid., vol. 6, no. 4, pp. 179–230, pls. 21 – 28, tables 6–8.

1948 – *The species of Bulimina and related genera in the collections of the Allan Hancock Foundation.* Ibid., vol. 6, no. 5, pp. 231–294, pls. 29–32, table 7.

TABLE 7

FAUNAL LIST OF DEAD SPECIMENS

NUMBERS REPRESENT PERCENTAGE OF EACH SPECIES IN THE BENTHONIC POPULATION – X REPRESENTS LESS THAN ONE PERCENT

STATION NUMBERS	PROFILE NO. 1	PROFILE NO. 2	PROFILE NO. 3	PROFILE NO. 4	PROFILE NO. 5	PROF. NO. 6	PROFILE NO. 7	PROFILE NO. 8	PROFILE NO. 9	PROFILE NO. 10	PROFILE NO. 11	PROFILE NO. 12	PROFILE NO. 13	PROFILE NO. 14	PROF. NO. 15	PROFILE NO. 16
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3599 3600	3607 3606 3608 3609 3610	3616 3617 3618 3614 3615 3613 3612 3611	3605 3604 3603 3602 3601	3976 3977 3978	3973 3974 3975	3997 3996 3995	3979 3980 3981	3982 3983 3984 3985 3993 3991 3994	3990 3989	3971 3987 3986
ANGULOGERINA ANGULOSA	14 18	26 16 13 17 11 6	9 14 7	6 13 7 6 11 7	8 21 8 8 7 8 10	24 6	5 4 7 7 3	X 3 4 8 5 4 3 8	1 12 5 10 5	11 15 8	7 4 12	1 1	2 7 8	11 5 4 11 5 X X	5	9 2 1
A. BAGGI		5 7 2 1	X X		1 2 X 7		X 2	1 2 5 2 1 4	1 1 1	2 1			1 2 1	1 5 1 X		1
A. CARINATA		X X X														
BOLIVINA ADVENA VAR ACUTULA		1	1 1	X 1 2 1 2	1	3 3	X 2 2	X 1	X X 1 1	X 1		1 X	X	X X X X 1 X	5 X	1
B. ACUMINATA	3 3	X 3 X	5 X	14 15 12 4	X X 1	5 1	X 3 2 1	X 1 X X	1 X 2	1 X X	1		X	X		
B. ARGENTEA							X X									
B. COMPACTA						X	X 4			3		3 X 1		2 1 1	5	
B. PACIFICA	3 2	1 1 2 X	3 4	15 4 6 3 1 1	X 1 2 1	7 2	X 4 7 1	X 1	X 1 X	1 1 1	1 X 2		1 X	X X 2 X	1 X	1 1
B. PSEUDOPLICATA	1 4	4 1 1 2 X X	3 2 5	1 X 1 6 4 2 2 5	X 2 1 7 4	1 4	1 2 X	X X X	1 1 2 9	5 10 6	3 1 4	6 4 X		2 1 6 4 2 2	1 7	1 3
B. QUADRATA	1 2	2 X	1 3	1 1 1 5 3 9 8 11	X X X 2 2 9	1 3	2 4 19	1 X X 2	X X 4	4 2 8	2 2 3	10 4 1	X	X X 2 5 11 2 4	5 9	2 3
B. TONGI											X			X		
BULIMINA AURICULATA	X 1		3 1	6 6 6 6	2	1	1 2 X									
B. DENUDATA	1 2	X X	6 X	10 10 7 3 6 7 9 1	X X 3 2	2 5	1 3 4 9	X X 1 3	X X 3 2	1 1 7	1	2 X	X	1 5 1 1	6 6	2
B. ELONGATA VAR. SUBULATA				X 1 1 X	X	X X	1 1		2							X
BULIMINELLA ELEGANTISSIMA				1 3 3	1	1	1 1					6		X 2 1		2
CANCRIS SAGRA	1 1	X 2 1 X X	6 1	3 6 13 5 2	X 1 X	4 X	1 1 1	X	X 1	1 1 1	X			X		
CASSIDULINA CALIFORNICA		X X	5 2	X 2 4 1 1	X X 1 1	5	3 1 1 1				X					
C. CARIBEANA		3	X	1	1 1 2 X X									1 X		
C. DELICATA					1	1				X						
C. LIMBATA	3 6	12 5 6	1	2 1 1 X	15 1 11 X 15	5	13 19 7 1	30 16 12 10 14 16 27 X	18 11 16 2	4 1	5 18 4		18 13 7	1 1 1		1
C. MINUTA	25 19	8 21 22 7 3 1	4 11 10	16 7 7 21 7 3 2 4	6 6 11 X 14 5	6 3	3 1 8 1 1	1 2 3 5 2 1 9 7	9 16 7 11 4	30 16 7	18 7 14	4 1 X	3 16 9	6 5 5 11 7 1 1	3 8	4 4
C. SUBGLOBOSA	33 32	22 25 22 30 46 16	9 22 38	3 5 7 17 10	17 11 21 4 14 29 10	14 21	9 11 33 31 5	11 12 14 11 13 8 18 22	11 20 11 52 7	12 19 6	19 8 40		10 18 27	13 7 12 16 1 X		32 2 3
C. TORTUOSA	X	1 5 2 5 1	44 X X	X	21 20 17 35	1 X	44 32 X X	46 38 42 21 35 36 21 9	28 11 29 1 X	1 3 1	14 32 1		38 17 19	22 34 27 X		9
CHILOSTOMELLA CZIZEKI	1			1												
CIBICIDES FLETCHERI	2 2 55	6 5 4 4 4 3	12 1 2	X 1 1 2 X 1 2	5 6 6 13 5 1 1	1 2	5 4	3 5 7 9 7 7 3 3	6 5 9 X 5	3 9 1	5 6 3	3 4 17	6 6 9	4 6 14 8 8 5 4	2	15 7 X
C. GALLOWAYI		2 1			12			1 4 X	X	1	X	1	X	2 4 2 1 X 2		2
C. LOBATUS		4 2 1 1 X 1	X	X 4	1 X 1 3 1 X	X	1 X	1 X 5	2 1 1 1 15	1 1 X	1	1 1 4	X 1	2 X 2 2 2 3	X	4 2
C. MCKANNAI	1 1	X 1 X X	X 1	X X X	5 4 3 3	X	2 5 X	4 11 3 2 4 6 4 4	5 1 4	1 X	5 5		6 4 2	5 3 4		3
C. REFULGENS		3 X	X X X	X	X 2 1 1	X	1 1	X 1 3 X X X X	X 1 X X	X	1 X		1 X X	2 2 1 X X		
DISCORBIS LAURIEI												1 1		6		
D. MONICANA	X X	2 1 6 22	2	X 1 7 2 X 8	7 X X 11	9	1	X 1 1	1 X X 7	4 3 3	1 1 2	10 21 5	X 2 2	2 1 1 4 9 5 10	9 5	3 4 4
DYOCIBICIDES BISERIALIS					1				1			X 2 1		1 1		2
EGGERELLA ADVENA					5 2	1 5	2 7 15	1	1 1	1 X 6				1 X X		1
EHRENBERGINA COMPRESSA	1	7 2 1 X X	1		1		2	X 2 2 X X	X		X			X		
ELPHIDIUM ARTICULATUM				2 1		X						X		X		
E. FAX SUBSP. FAX			X		X X		1	1 2 1 2 X	1 X		X	X	X	X 1	2	X
E. RUGULOSUM		2	X X 2	1 3 19 30 15	X 2	1 6	1 1 1 7	1 X X X	3 1 X 4	2 X 1	X 1 2	15 6 X		1 X 1 5 6 22 22	1 7	10 37
E. TRANSLUCENS	X X	1	1	13 32 15 5	1 3	8	5	X X	X 5	1 3	X X	1 3 1	X	2 6 14 12 3	13 24	6
EPISTOMINELLA BRADYANA		4 2 X	9 7 2	9 11 3 7 1 X	X X 1 X 3 7	2 1	X 8 3 2	X 1 X 1 1	X 1 2 2 1	5 3 3	4 2			X X 1		
E. LEVICULA				7 2	1 2 1	3	2 X	1 X X		3 1	1 X 1			X		
EPONIDES SP.				3	X											
FISSURINA SPP.	2 2	2 1 X X 1 2	1 4 2	2 3 2 2 3 5 3 1	1 X X 2 3 1	2 1	X X X 1	X X X	1 1 1	2 3	1 X 1	8 X		1 2 X	X	
GAUDRYINA ARENARIA	2 1	X 5 1	X 1	1 1 1	7 1 1 X	X	1 4 1	X 1 1 X 1 2 4 1	6 2 1 X	1	2 1 1		X 3	X		
G. ATLANTICA VAR PACIFICA	1 1	5 3 4 5 1	1 X 1		X 1 1 X X 1	X X	X	X X X 1 1 2		1			X	2 X X		
G. SUBGLABRATA		3 2 1 5	X		X	1	X X	1	X				X			
GOESELLA FLINTI							X							X		
GUTTULINA QUINQUECOSTA	X	X												X X		
HANZAWAIA BASILOBA VAR NITIDULA	1	X 1 X X			X 1 X	1 X	X	X 1 X 2	1 X 1	1 X 1	X 1 1		1	X X 1		1
HAPLOPHRAGMOIDES ADVENA	X	X	2 1	X 1 1 1	1 2	1 1	X 1 1 1		X			2		X	6	
H. COLUMBIENSE VAR. EVOLUTUM										X		X				1
HOEGLUNDINA ELEGANS			1		1 X		2	1	1		2		1			
HOPKINSINA PACIFICA				2 2			2			2		X		2 X	4 4	
INVOLUTINA PACIFICA							1									
LAGENA SPP.	1 2	1 1 X 1 1	X 2 4	3 7 8 2 1 X	1 X 2 3	2 2	X X 1 3 2	X 1	X X 3 1	1 1	1	1 X	1	1 1 1 1 X	1 3	
SPECIES OF MILIOLIDS	1	2 1 14		X 1 2 15	1 6 2	2	1 1 X X 2	X 3 X X 1	1	1 X X	3	13 14 6	1	6 2 1 1 4 17 6	15 4	2 12 16
MILIOLINELLA SP.														1		
NONIONELLA BASILOBA		X	X 1	X X X		X X	X		X							
N. BASISPINATA		X	X	X 3 1	X 1	1	X 3	1	1 2	X X	X	1	X	1 X 2 5 2	3 1	
N. MIOCENICA VAR. STELLA					1	X										
PATELLINA CORRUGATA				1												
PLANULINA ARIMINENSIS	1 X	X X 2 1 X 2	1	X	1 2 3 7 X X	1 1	3	1 3 3 6 4 4 2 2	X 1 2 X X	1 1 X	1 1 X		4 4 5	5 8 6 2		5
P. ORNATA	X	X X X 2 1 1	X	1 1	1 1 3 5 1 1	X X	1	X 2 1 3 1 2	X X 3 X	1	1 1 X		X 1	2 1 2 2		1
P. SP.					1			2	1		1	X		X X X		1
PLANORBULINA MEDITERRANENSIS	1								X							
POROEPONIDES CRIBROREPANDUS		1	1		X 5			X						1 1 X		
PROTEONINA ATLANTICA		X 1	X	1 X X X	1 1	2 1	1 3 6	2	X 2	2				1		
P. GRZYBOWSKI							1									
PULLENIA SALISBURYI		X 1 1	1 X	X 1 2 X	1 1 X X	1	1 2 1	1	1	X X	1			1 X		
PYRGO OBLONGA				1								X		10	2 X	
P. SP.		X				X X										
QUINQUELOCULINA BIDENTATA				1 X								1 4 2		10		28 1
Q. CATALINENSIS																
Q. ELONGATA	2	X						X X						1		
Q. FLEXUOSA				X												
Q. GIGAS					1							1	X			
Q. JUGOSA	7				1 X				1			1 2				
Q. LAEVIGATA												1 6 13		25		
Q. LAMARCKIANA	2	2 X X	X	1 X 1	1 1	X	X	1 X				X 1 5		X 1		3
Q. POEYANA				X 2	X							9 1		3		5
Q. SABULOSA	1	1 1	X X	X 1 X	X X		X	X X	X	X		X	X	X		2
Q. SP. A					4	1			X				1	2		
Q. SP. B	6	X			3				X							
Q. SP. C				3								1 10		1		5
RECURVOIDES CONTORTUS				1 X	X	X 1	X 1 1			1						
REOPHAX EXCENTRICUS							X X									
R. SCORPIURUS			X X				X									
R. SP.							2 1	1								
ROBERTINA CHARLOTTENSIS		X	X	X	X		X X							X		1
ROBULUS CULTRATUS				1 X								X X		X 1		
ROTORBINELLA LOMAENSIS								1				1	X	1 1		
R. TURBINATA	13				1 1				X			10				
R. VERSIFORMIS	1 X	1 2 1 11	X 1 2	2 6	4 1 1 4 5 11	1 3	3 X X	X 2 4 2 1 X 7	1 3 6 1 4	2 2 4	2 4 1	6 6 10	5 4 4	3 4 6 5 1 X 3	1 X	8 7 2
RUPERTIA STABILIS							2									
SIGMOILINA TENUIS	1 X	X			X X		X X X	X 1 X X	X 1		X X		X			
SPIROLOCULINA DEPRESSA		X			X			X								
STREBLUS TEPIDUS				1 6						X						
TEXTULARIA ARTICULATA		X			2				X							
T. CANDEIANA		1 1 X 6 2	X 1	X X 1 1 6	X 2 1	X 6	X 1 2	6	1 6	3	X 1		1	X 1	1	1 X
T. EARLANDI					5		1 3 X			X	X					X
T. SCHENCKI	13	4	3	7 X	X 4 13	X 3			X 6			1 X		7 1 3	3	1
T. SP.		X 2												X		
TRILOCULINA LAEVIGATA				3 2 2		X						1		1	6 X	8
T. ROTUNDA		1 X 1										X		4		
T. TRIGONULA		X	X	X X					X							
TROCHAMMINA PACIFICA		X X	X X	X X 1	1	X X	1 1 X			X 3		2 2		1 X		1 1 X
T. SQUAMIFORMIS				1 X	X 1		X							X		
UVIGERINA HOLLICKI				6 3 1			X									
U. JUNCEA	1	1	X	1 1		1	X				X					
VIRGULINA SCHREIBERSIANA				8								1		X X 2	8 X	
V. SP.				2 X			X			1 1		X		X	7	

Table 8

Faunal list of Living specimens

NUMBERS REPRESENT PERCENTAGE OF EACH SPECIES IN THE BENTHONIC POPULATION

	PROF. NO. 1		PROFILE NO. 2			PROF. NO. 3		PROFILE NO. 4			PROFILE NO. 5							PROF. NO. 6		PROFILE NO. 7		
STATION NUMBERS	3570	3571	3572	3573	3574	3579	3580	3581	3587	3588	3592	3593	3595	3596	3597	3598	3591	3599	3600	3608	3609	3610
ANGULOGERINA ANGULOSA	3		3	3	2	5					4	3			4					3	2	
BOLIVINA ACUMINATA	26			3		5	11	4			13	12			18		5			22	6	3
B. ADVENA VAR. ACUTULA	1				14					7	11	12							11	5	16	3
B. COMPACTA					5																4	10
B. PACIFICA	47		72	46	38	10	39	70			21	19			4	67	27	50	53	11	21	4
B. PSEUDOPLICATA										4	2	2								2	1	
B. QUADRATA									16	25	1	1			4						4	36
B. TONGI																						
BULIMINA AURICULATA						15	17				1	1			8					1	4	
B. DENUDATA	3				1	30		20	14	4	5	2			15				5	5	2	8
B. ELONGATA VAR. SUBULATA																						1
BULIMINELLA ELEGANTISSIMA									19	22					4				5		1	1
CANCRIS SAGRA	15		13	27	25	30	6	6			17	30			4		39	50		12	7	
CASSIDULINA DELICATA																			2		1	
C. LIMBATA																				1		
C. MINUTA	1									2	3	3		17			14					
C. SUBGLOBOSA				2							2	4		67	4				2	9	6	4
C. TORTUOSA																						
CIBICIDES FLETCHERI				1							1											
C. LOBATUS																						
C. MCKANNAI																						
DISCORBIS LAURIEI																						
D. MONICANA					1																	
EGGERELLA ADVENA																				1	4	4
EHRENBERGINA COMPRESSA			6																			
ELPHIDIUM RUGULOSUM									19	25												1
E. TRANSLUCENS									6	5												4
EPISTOMINELLA BRADYANA				6	5	5					7	1			4				2		4	1
E. LEVICULA												1								4	1	1
FISSURINA SPP.								1	1								5					
GAUDRYINA ATLANTICA VAR. PACIFICA											1	1		18								
G. SUBGLABRATA											1											
GUTTULINA QUINQUECOSTA																						
HANZAWAIA BASILOBA VAR. NITIDULA			6		7						4				4							
HAPLOPHRAGMOIDES ADVENA				1								2					5			3	5	1
HOPKINSINA PACIFICA									8													4
LAGENA SPP.											1	2							2	2	1	
SPECIES OF MILIOLIDS										4			50									1
NONIONELLA BASILOBA	2						27				1	1							2	2		
N. BASISPINATA									1							33			12			5
N. MIOCENICA VAR. STELLA															8							
PLANULINA ARIMINENSIS																						
PROTEONINA ATLANTICA																					1	3
PULLENIA SALISBURYI											1	1								6		
QUINQUELOCULINA JUGOSA																						
Q. LAEVIGATA																						
Q. LAMARCKIANA																						1
Q. POEYANA																						
RECURVOIDES CONTORTUS																					2	1
REOPHAX SP																					4	
ROBERTINA CHARLOTTENSIS											1								4	2		1
ROBULUS CULTRATUS																						
ROTORBINELLA VERSIFORMIS					1																	
TEXTULARIA ARTICULATA		100																				
T. EARLANDI																				2	3	
T. SCHENCKI													50									2
TRILOCULINA LAEVIGATA									1													
TROCHAMMINA PACIFICA				1	1															2		
UVIGERINA HOLLICKI												2										
U. JUNCEA	2			10							2						5			5		
VIRGULINA SCHREIBERSIANA									5													
V. SP.									8	4					15							

	PROFILE NO. 8								PROF. NO. 9		PROFILE NO. 10			PROF. NO. 11		PROFILE NO. 13			PROFILE NO. 14							PROFILE NO. 16	
STATION NUMBERS	3618	3617	3616	3615	3614	3613	3612	3611	3602	3601	3976	3977	3978	3974	3975	3979	3980	3981	3982	3983	3984	3985	3993	3991	3994	3987	3988
ANGULOGERINA ANGULOSA				15	1	19	2			1							2		9		2						
BOLIVINA ACUMINATA				5		16	5	2				8	2		17		16	12	26		5						
B. ADVENA VAR. ACUTULA				3		2	2	15		9		18	8				5	7	5	34	37	22	2	2			
B. COMPACTA													12														
B. PACIFICA	95	100	89	15	19	8	48	2	20	13	76	35	8	50	50	71	50	55	9	34	31	67	4	2			
B. PSEUDOPLICATA				5		2	2	4		3		2			3					2	5			2			
B. QUADRATA								11	20	16			10		3	1							12		3		3
B. TONGI			11	10															9								
BULIMINA AURICULATA												8					2										
B. DENUDATA							5	4		2	6		10				3	5		2			14	8			5
B. ELONGATA VAR. SUBULATA																											
BULIMINELLA ELEGANTISSIMA								2		1			2										2	32	5		5
CANCRIS SAGRA	3				19	20	5	17	20	2	18	13	12	50	12	4	12	5	22		9						
CASSIDULINA DELICATA																											
C. LIMBATA	2				6	2	3									1			2								
C. MINUTA						2		7		2		2	3		7	4		2	7	4			32	2			3
C. SUBGLOBOSA				5	19		3	9		1		2			5			1	2		2						
C. TORTUOSA													2														
CIBICIDES FLETCHERI							2																				
C. LOBATUS				5						2																	
C. MCKANNAI							2																				
DISCORBIS LAURIEI																									18		
D. MONICANA						2																					
EGGERELLA ADVENA								7								1											
EHRENBERGINA COMPRESSA																											
ELPHIDIUM RUGULOSUM																								38	51		57
E. TRANSLUCENS								4															2				
EPISTOMINELLA BRADYANA				5		10	6	2		2		2				6					2		2				
E. LEVICULA												2															
FISSURINA SPP.										1																	
GAUDRYINA ATLANTICA VAR. PACIFICA								2																			
G. SUBGLABRATA																											
GUTTULINA QUINQUECOSTA										1																	
HANZAWAIA BASILOBA VAR. NITIDULA				30	25	10		2					2			11	2		9	5	3						
HAPLOPHRAGMOIDES ADVENA							2										3										
HOPKINSINA PACIFICA												2	10					1			2	4	6	2			
LAGENA SPP.																				7							
SPECIES OF MILIOLIDS						2				1													18				22
NONIONELLA BASILOBA									20								2				2						
N. BASISPINATA								4	20	27		4	10		3		3	5				7	4				
N. MIOCENICA VAR. STELLA					6		11											1									
PLANULINA ARIMINENSIS					6	5																					
PROTEONINA ATLANTICA																											
PULLENIA SALISBURYI												2	2							7							
QUINQUELOCULINA JUGOSA										2																	
Q. LAEVIGATA																									18		
Q. LAMARCKIANA																											
Q. POEYANA																									5	50	
RECURVOIDES CONTORTUS													2														
REOPHAX SP																											
ROBERTINA CHARLOTTENSIS							2																				
ROBULUS CULTRATUS										1														2			
ROTORBINELLA VERSIFORMIS								4		4																50	5
TEXTULARIA ARTICULATA																											
T. EARLANDI																											
T. SCHENCKI								2		3																	
TRILOCULINA LAEVIGATA																											
TROCHAMMINA PACIFICA													2														
UVIGERINA HOLLICKI																											
U. JUNCEA																											
VIRGULINA SCHREIBERSIANA										6														5			
V. SP.													3			1		6					2	5			

1950 – *Some Lagenidae in the collections of the Allan Hancock Foundation.* Ibid., vol. 6, no. 6, pp. 295–364, pls. 37–48.

CUSHMAN, J. A., AND MOYER, D. A.
1930 – *Some Recent foraminifera from off San Pedro, California.* Cushman Lab. Foram. Res., Contr., vol. 6, pt. 3, pp. 49–62, pls. 7–8.

CUSHMAN, J. A., AND VALENTINE, W. W.
1930 – *Shallow-water foraminifera from the Channel Islands of southern California.* Stanford, Univ., Dept. Geol., Contr., vol. 1, no. 1, pp. 1–31, pls. 1–10.

CUSHMAN, J. A., AND WICKENDEN, R. T. D.
1929 – *Recent foraminifera from off Juan Fernandez Islands.* U. S. Nat. Mus., Proc., vol. 75, art. 9, pp. 1–16, pls. 1–6.

DANA, S. W.
[MS.] *A sedimentary study of bottom mud samples dredged by the Velero III.* Univ. Southern California, unpublished Master's thesis in geology, 47 pp. (1942).

EMERY, K. O.
1938 – *Rapid method of mechanical analysis of sands.* Jour. Sed. Petrol., vol. 8, no. 3, pp. 105–111.

FARRAND, W. H.
[MS.] *The relation of a fossil foraminifera fauna from Timms Point, San Pedro, California, to a Recent foraminifera fauna from off the coast of San Pedro, California.* Univ. Southern California, unpublished Master's thesis in geology, 26 pp. (1929).

GALLOWAY, J. J., AND HEMINWAY, C. E.
1941 – *The Tertiary foraminifera of Porto Rico.* New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3 (1920–1941), pt. 4, pp. 275–491, pls. 1–36.

GALLOWAY, J. J., AND WISSLER, S. G.
1927 – *Pleistocene foraminifera from the Lomita Quarry, Palos Verdes Hills, California.* Jour. Pal., vol. 1, no. 1, pp. 35–87, pls. 7–12.

JENKINS, O. P.
1943 – *Geomorphic provinces of California.* California, Div. Mines, Bull., no. 118, pp. 83–88.

KRUMBEIN, W. C., AND PETTIJOHN, F. J.
1938 – *Manual of sedimentary petrography.* New York: Appleton-Century-Crofts, 549 pp.

LALICKER, C. G., AND MCCULLOCH, I.
1940 – *Some Textulariidae of the Pacific Ocean.* Allan Hancock Pacific Exped., vol. 6, no. 2, pp. 115–143, pls. 13–16.

LAWSON, A. C.
1898 – *The Post Pliocene Diastrophism of the Coast of Southern California.* California, Univ. Dept. Geol. Sci., Bull., vol. 1, pp. 115–160.

LOEBLICH, A. R., AND TAPPAN, H.
1954 – *Emendation of the foraminiferal genera Ammodiscus Reuss, 1862, and Involutina Terquem, 1862.* Washington Acad. Sci., Jour., vol. 44, no. 10, pp. 306–310, text-figs. 1–2.

MOYER, D. A.
[MS.] *The relation of a fossil foraminifera fauna from Lomita Quarry, San Pedro, California, to a Recent foraminifera fauna from off the coast of San Pedro, California.* Univ. Southern California, unpublished Master's thesis in geology, 22 pp. (1929).

NATLAND, M. L.
1933 – *The temperature and depth distribution of some Recent and fossil foraminifera in the southern California region.* Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 3, no. 10, pp. 225–230, table.

1938 – *New species of foraminifera from off the west coast of North America and from the later Tertiary of the Los Angeles basin.* Ibid., Tech. Ser., vol. 4, no. 5, pp. 137–164, pls. 3–7.

PHLEGER, F. B.
1951 – *Displaced foraminifera faunas.* Soc. Econ. Pal. Min., Spec. Publ. no. 2, pp. 66–75, text-figs. 1–7.

REVELLE, R.
1950 – *Physical and chemical data.* California, Univ., Scripps Inst. Oceanogr.

REVELLE, R., AND SHEPARD, F. P.
1939 – *Sediments off the California coast.* In: TRASK, P. D., *Recent marine sediments, a symposium.* Tulsa, Oklahoma: Amer. Assoc. Petrol. Geol., pp. 245–282.

SHEPARD, F. P., AND EMERY, K. O.
1941 – *Submarine topography off the California coast: Canyons and tectonic interpretation.* Geol. Soc. Amer., Spec. Paper no. 31, 171 pp.

SHEPARD, F. P., GRANT, U. S., AND DIETZ, R. S.
1939 – *The emergence of [Santa] Catalina Island.* Amer. Jour. Sci., vol. 237, pp. 651–655.

SHEPARD, F. P., AND MACDONALD, G. A.
1938 – *Sediments of Santa Monica Bay, California.* Amer. Assoc. Petrol. Geol., Bull., vol. 22, no. 2, pp. 201–216.

SHEPARD, F. P., AND WRATH, W. F.
1937 – *Marine sediments around Catalina Island.* Jour. Sed. Petrol., vol. 7, no. 2, pp. 41–50.

SMITH, W. S. T.
1897 – *The geology of Santa Catalina Island, California.* California Acad. Sci., Proc., ser. 3, Geology, vol. 1, pp. 1–71.

1933 – *Marine terraces on Santa Catalina Island.* Amer. Jour. Sci., ser. 5, vol. 25, pp. 123–136.

SVERDRUP, H. U., JOHNSON, M. W., AND FLEMING, R. H.
1952 – *The oceans.* Ed. 4. New York: Prentice-Hall, 1060 pp.

TABER, S.
1927 – *Fault troughs.* Jour. Geol., vol. 35, pp. 595–597.

TRASK, P. D.
1931 – *Sedimentation in the Channel Islands region.* Econ. Geol., vol. 26, pp. 24–43.

WALTON, W. R.
1952 – *Techniques for recognition of living foraminifera.* Cushman Found. Foram. Res., Contr., vol. 3, pt. 2, pp. 56–60.

1955 – *Ecology of living benthonic foraminifera, Todos Santos Bay, Baja California.* Jour. Pal., vol. 29, no. 6, pp. 952–1018, pls. 99–104, text-figs. 1–24, tables 1–7.

WOODFORD, A. O.
1924 – *The Catalina metamorphic facies of the Franciscan series.* California, Univ., Publ. Geol., vol. 15, no. 3, pp. 49–68

Contribution no. 238 of the Allan Hancock Foundation, University of Southern California, Los Angeles.

ABSTRACT: *During 1957, sixty-nine papers pertaining to Ostracoda were published, so far as now known. They contain descriptions of seventy-three new genera and 388 new species. The new forms range in age from Lower Paleozoic to Recent.*

Bibliography and index to new genera and species of Ostracoda for 1957

STUART A. LEVINSON
Humble Oil & Refining Company
Houston, Texas

Sixty-nine papers pertaining to ostracodes are known to have been published in the year 1957 (text-fig. 1). This is in contrast to the seventy-nine papers now known to have been published in 1956. In 1957, seventy-three new genera are known to have been described (text-fig. 2); this compares with the eighty-nine new genera described in 1956. The new genera described in 1957 again span the geologic column, with twenty-seven Paleozoic genera, twenty-one Mesozoic genera, eighteen Cenozoic genera, and seven Recent genera.

During 1957, three hundred eighty-eight new species were described (text-fig. 3), as opposed to four hundred seventy-eight in 1956 and two hundred sixty-six in 1955.

The author is again grateful to the many ostracode workers who have generously sent him reprints of their papers and of other papers as they appeared. He is particularly indebted to Lee Gibson, Dr. H. V. Howe, Dr. M. Mandelstam, R. W. Morris, Mrs. Betty Kellett Nadeau, Dr. H. S. Puri, and I. G. Sohn.

In the following bibliographies, general papers containing no new forms of ostracodes are marked with an asterisk (*).

BIBLIOGRAPHY OF OSTRACODA FOR 1957

ABUSIK, A. F.
1957 – *Silurian ostracode complex of the Siberian Platform.* Leningrad, Univ., Publ., no. 6 (Geol. Geogr. Ser., no. 1), pp. 5–15. (Original not seen; translation distributed by the Uppsala University Institute of Paleontology indicates many *nomina nuda*: *Sibiritia, Tallinella, Gibberella, Sollinella, Costaegera,* and many species.)

AGNEW, A. F.
1957 – *Ostracodes of the Paleozoic.* In: *Treatise on marine ecology and paleoecology.* Geol. Soc. Amer., Mem., no. 67, vol. 2, pp. 931–936.

AMSDEN, T. W.
*1957 – *Catalog of Middle and Upper Ordovician fossils.* Oklahoma, Geol. Survey, Circ., no. 43, pp. 1–41.

BOLD, W. A. VAN DEN
1957*a* *Ostracoda from the Paleocene of Trinidad.* Micropaleontology, vol. 3, no. 1, pp. 1–18, pls. 1–4, 1 text-fig.

1957*b* *Oligo-Miocene Ostracoda from southern Trinidad.* Micropaleontology, vol. 3, no. 3, pp. 231–254, pls. 1–4, text-figs. 1–2.

*1957*c* *Some ostracode homonyms.* Jour. Pal., vol. 31, no. 5, pp. 950–951.

BROWN, P. M.
1957 – *Upper Cretaceous Ostracoda from North Carolina.* North Carolina, Dept. Cons. Devel., Div. Min. Res., Bull., no. 70, pp. 1–28, pls. 1–7, 1 text-fig.

BUTLER, E. A., AND JONES, D. E.
1957 – *Cretaceous Ostracoda of Prothro and Rayburns salt domes, Bienville Parish, Louisiana.* Louisiana, Geol. Survey, Geol. Bull., no. 32, pp. 1–65, pls. 1–6, 5 text-figs.

COOPER, C. L.
1957 – *New names for species of Bairdia and Amphissites.* Jour. Pal., vol. 31, no. 3, p. 674.

COPELAND, M. J.
1957 – *A new species of the ostracod genus Knoxiella from the Middle Devonian Ludlowville formation of western New York.* Jour. Pal., vol. 31, no. 5, pp. 931–933, pl. 114, 1 text-fig.

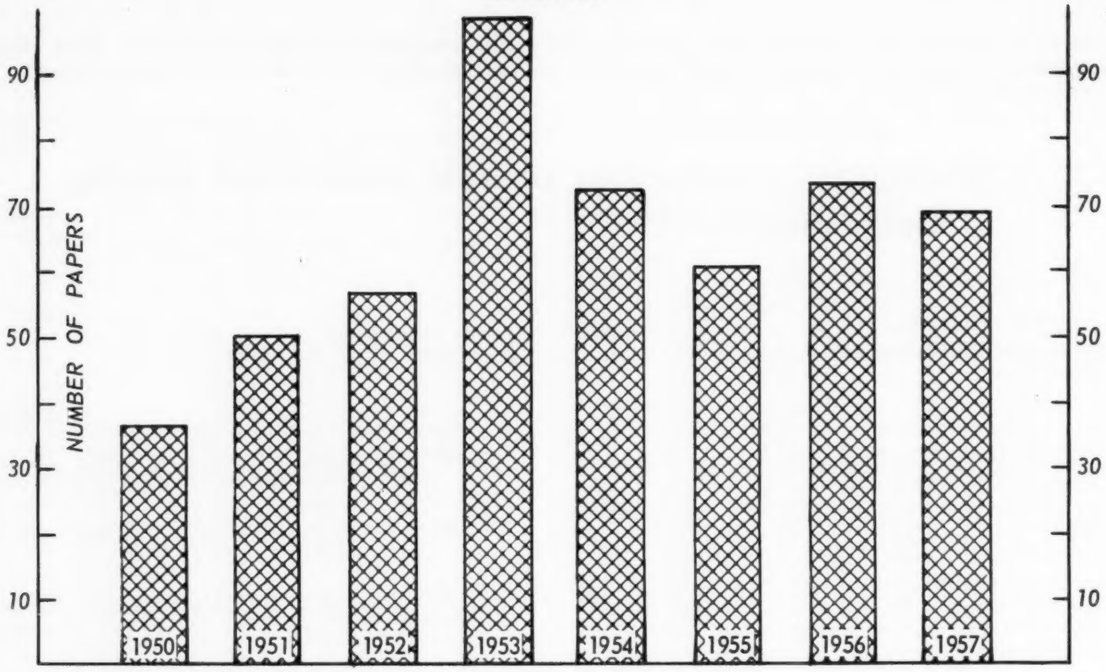
DANISCH, E.
*1957 – *Beitrag zur Stratigraphie des Doggers am Voßberge südlich Engters (Wiehengebirge).* Naturw. Ver. Osnabrück, Veröff., vol. 28, pp. 41–49, 1 table.

FERGUSON, E., JR.
1957 – *Ostracoda (Crustacea) from the northern Lower Peninsula of Michigan.* Amer. Microsc. Soc., Trans., vol. 76, no. 2, pp. 212–218, 4 text-figs.

GILL, E. D.
1957 – *The stratigraphical occurrence and paleoecology of some Australian Tertiary marsupials; C-Occurrence of Tertiary marsupials at Beaumaris, Victoria.* Nat. Mus. Victoria, Mem., no. 21, pp. 165–203 (ostracodes, pp. 171, 176, 183, 184, text-fig. 17).

GOCHT, H., AND GOERLICH, F.
*1957 – *Reste des Chitin-Skelettes in fossilen Ostracoden-Gehäusen.* Geol. Jahrb., vol. 73, pp. 205–214, 3 text-figs.

GOERLICH, F.
1957 – *Bemerkungen zu "Ostrakoden der Cytherideinae aus der Tertiären Molasse Bayerns."* Hesse, Landesamt Bodenf., Abh., vol. 23, pp. 77–86.



TEXT-FIGURE 1

AN ANALYSIS OF THE NUMBER OF PAPERS PERTAINING TO OSTRACODES FROM 1950–1957

GREILING, L.
*1957 – *Der Kalk der Löhmar-Mühle.* Senckenbergiana Lethaea, vol. 38, no. 3/4, pp. 251–259 (ostracodes, pp. 252, 257).

GRÉKOFF, N.
1957 – *Ostracodes du Bassin du Congo; 1–Jurassique supérieur et Crétacé inférieur du Nord du Bassin.* Mus. Roy. Congo Belge, Ann., Tervuren, Belgium, ser. 8 (Sci. Géol.), vol. 19, pp. 1–97, pls. 1–6, 38 text-figs.

HANAI, T.
1957a *Studies on the Ostracoda from Japan; 1–Subfamily Leptocytherinae, new subfamily.* Tokyo, Univ., Fac. Sci., Jour., sec. 2, vol. 10, pt. 3, pp. 431–468, pls. 7–10, 2 text-figs.
1957b *Studies on the Ostracoda from Japan; 2–Subfamily Pectocytherinae, new subfamily.* Tokyo, Univ., Fac. Sci., Jour., sec. 2, vol. 10, pt. 3, pp. 469–482, pl. 11, 6 text-figs.
1957c *Studies on the Ostracoda from Japan; 3–Subfamily Cytherurinae G. W. Müller (emend. G. O. Sars, 1925) and Cytheropterinae, new subfamily.* Tokyo, Univ., Fac. Sci., Jour., sec. 2, vol. 11, pt. 1, pp. 11–36, pls. 2–4, 9 text-figs.

HARRIS, R. W.
1957 – *Ostracoda of the Simpson Group.* Oklahoma, Geol. Survey, Bull., no. 75, pp. 1–333, pls. 1–10.

HARTMANN, G.
1957a *Zur Kenntnis des Mangrove-Estero-Gebietes von El Salvador und seiner Ostracoden-Fauna; II.* Kieler Meeresf., vol. 13, no. 1, pp. 134–159, pls. 39–50.
1957b *Neue Funde von Muschelkrebsen (Ostracoda) im Gebiete der Nordseeküste und der Kieler Bucht (mit Beschreibung einer neuen Art).* Naturw. Ver. Schleswig-Holstein, Schriften, vol. 28, no. 2, pp. 103–111, text-figs. 1–17.
1957c *Ostrakoden aus dem Namaland und Transvaal.* Naturw. Ver. Osnabrück, Veröff., vol. 28, pp. 50–60, 21 text-figs.
1957d *Ostracoden aus den Mangroven Brasiliens.* Zool. Anzeiger, vol. 158, no. 9/10, pp. 209–217, 25 text-figs.

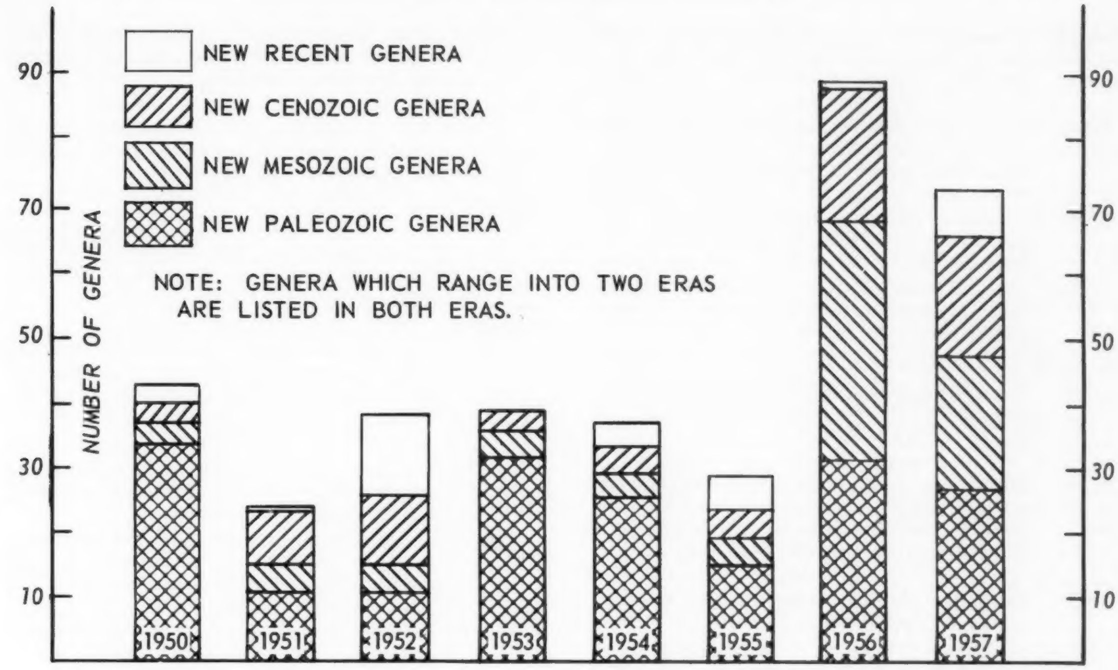
HERBST, H.
1957 – *Neue Cypridae (Crustacea Ostracoda) aus Australien; I.* Zool. Anzeiger, vol. 158, no. 9/10, pp. 217–225, 19 text-figs.

HILTERMANN, H.
*1957 – *Annotated bibliography of micropaleontology in Germany for 1956.* Micropaleontology, vol. 3, no. 4, pp. 399–406

JAANUSSON, V.
1957 – *Middle Ordovician ostracodes of central and southern Sweden.* Uppsala, Univ., Geol. Inst., Bull., vol. 37, pts. 3/4, pp. 173–442, pls. 1–15, 46 text-figs., 10 tables.

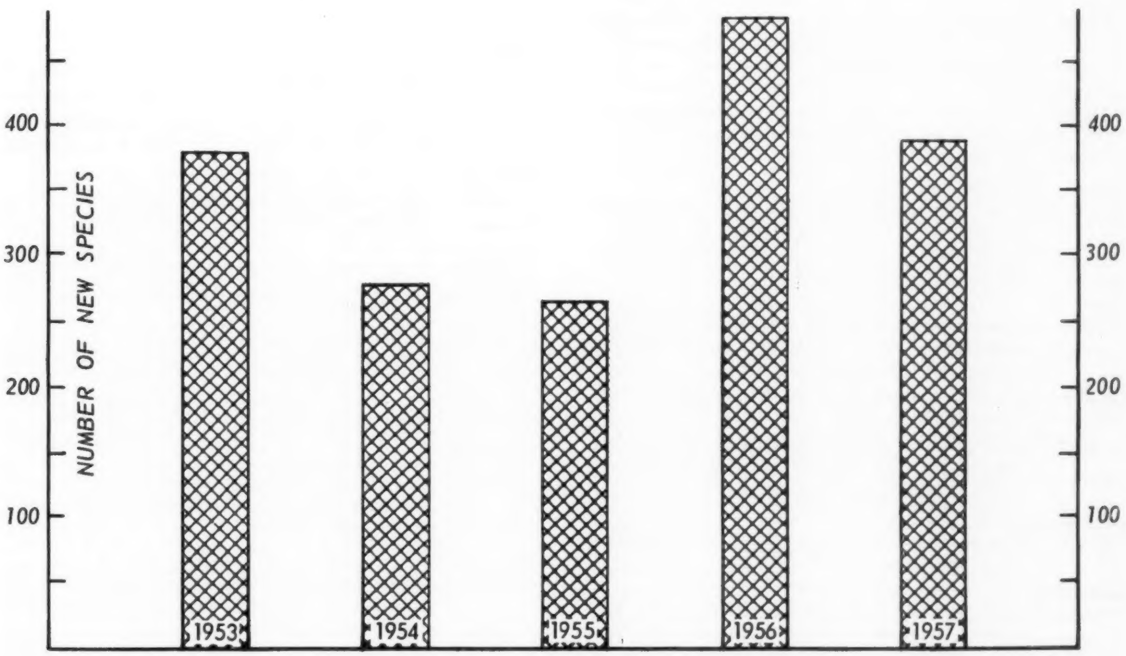
KEIJ, A. J.
1957 – *Eocene and Oligocene Ostracoda of Belgium.* Inst. Roy. Sci. Nat. Belgique, Mém., no. 136, pp. 1–210, pls. 1–23, 9 text-figs.

KESLING, R. V.
*1957a *A chart useful for study of ostracod carapaces.* Michigan, Univ., Mus. Pal., Contr., vol. 14, no. 2, pp. 17–20.



TEXT-FIGURE 2

AN ANALYSIS OF THE STRATIGRAPHIC DISTRIBUTION OF NEW GENERA OF OSTRACODES PROPOSED FROM 1950–1957



TEXT-FIGURE 3

AN ANALYSIS OF THE NUMBER OF NEW SPECIES OF OSTRACODES PROPOSED FROM 1953–1957

1957*b* *A new genus and species of ostracod from the Middle Devonian Ludlowville formation in western New York.* Michigan, Univ., Mus. Pal., Contr., vol. 14, no. 3, pp. 21–26, pl. 1.

*1957*c* *A peel technique for ostracod carapaces, and structures revealed therewith in Hibbardia lacrimosa (Swartz and Oriel).* Michigan, Univ., Mus. Pal., Contr., vol. 14, no. 4, pp. 27–40, pls. 1–5.

*1957*d* *Origin of beyrichiid ostracods.* Michigan, Univ., Mus. Pal., Contr., vol. 14, no. 6, pp. 57–80, pls. 1–7, text-figs. 1–5.

1957*e* *Notes on Zenker's Organs in the ostracod Candona.* Amer. Midland Nat., vol. 57, no. 1, pp. 175–182, text-figs. 1–9.

KESLING, R. V., AND ROGERS, K. J.
1957 – *Size, lobation, velate structures, and ornamentation in some beyrichiid ostracods.* Jour. Pal., vol. 31, no. 5, pp. 997–1009, pls. 127–130.

KESLING, R. V., AND SORONEN, G. C.
*1957 – *The ontogeny and ecology of Welleria aftonensis Warthin, a Middle Devonian ostracod from the Gravel Point formation of Michigan.* Michigan, Univ., Mus. Pal., Contr., vol. 14, no. 5, pp. 41–55, pls. 1–4.

KORNICKER, L. S.
*1957*a* *Bibliography of ostracode theses.* Micropaleontology, vol. 3, no. 3, pp. 287–290.

*1957*b* *Concentration of ostracodes by alcohol flotation.* Jour. Pal., vol. 31, no. 5, p. 1030.

LAURENCICH, L.
1957 – *Stillina, a new genus of Cretaceous Ostracoda.* Jour. Pal., vol. 31, no. 2, pp. 455–457, 1 text-fig.

LEVIN, H. L.
*1957 – *Micropaleontology of the Oldsmar limestone (Eocene) of Florida.* Micropaleontology, vol. 3, no. 2, pp. 137–154, pls. 1–4, text-figs. 1–2.

LEVINSON, S. A.
*1957 – *Bibliography and index to new genera and species of Ostracoda for 1956.* Micropaleontology, vol. 3, no. 4, pp. 367–392, 4 text-figs.

LYS, M., SERRE, B., AND DEROO, G.
1957 – *Études micropaléontologiques dans le Paléozoique de la Montagne Noire.* Inst. Franç. Pétrole, Rev., vol. 12, no. 7/8, pp. 783–809, pls. 1–12 (ostracodes, pp. 784, 786, 787–791, 794, pls. 1–2).

MALZ, H.
1957 – *Macrodentina maculata n. sp., ein stratigraphisch wichtiger Ostracod im oberen Malm.* Senckenbergiana Lethaea, vol. 38, no. 3/4, p. 250.

MANDELSTAM, M. I., SCHNEIDER, G. F., KUZNETSOVA, Z. V., AND KATZ, F. I.
1957 – *[New genera of ostracodes in the families Cypridae and Cytheridae].* All-Union Paleontological Society, Annual (Annals), vol. 16, pp. 166–192, pls. 1–4.

MARPLE, M. F.
*1957 – *Note on Sansabella stewartae Marple.* Micropaleontology, vol. 3, no. 1, p. 84.

MARTIN, G.
1957*a* *Die Fauna des Otolithen Pflasters; I–Ostracoden.* In: MARTIN, G. AND WEILER, W., *Das Aldorfer Otolithen "Pflaster" und seine Fauna.* Senckenbergiana Lethaea, vol. 38, no. 3/4, pp. 211–249, pls. 1–3 (ostracodes, pp. 211–227, 247, pls. 1–2).

*1957*b* *A new method of recovering remains of the chitinous integument of fossil Ostracoda.* Micropaleontology, vol. 3, no. 3, pp. 291–292.

McLEAN, J. D., JR.
1957 – *The Ostracoda of the Yorktown formation in the York-James Peninsula of Virginia.* Bull. Amer. Pal., vol. 38, no. 167, pp. 57–103, pls. 7–12.

MILLER, H. W., AND SWINEFORD, A.
*1957 – *Paleoecology of nodulose zone at top of Haskell limestone (Upper Pennsylvanian) in Kansas.* Amer. Assoc. Petr. Geol., Bull., vol. 41, no. 9, pp. 2012–2036 (ostracodes, pp. 2027–2028, 2034).

MOOS, B.
*1957 – *Die Ostracoden-Gattung Triginglymus D. B. Blake, 1950, als Synonym von der Gattung Leguminocythereis H. V. Howe, 1936.* Geol. Jahrb., vol. 72, pp. 501–502.

OERTLI, H. J.
1957*a* *Ostracodes du Jurassique supérieur du Bassin de Paris (Sondage Vernon 1).* Inst. Franç. Pétrol., Rev., vol. 12, no. 6, pp. 647–695, pls. 1–7.

1957*b* *Ostracoda.* In: BERNARD, F., BIZON, J., AND OERTLI, H. J., *Ostracodes lacustres du Bathonien du Poitou (Bassin de Paris).* Soc. Géol. France, Bull., ser. 6, vol. 6 (1956), fasc. 6, pp. 753–770, pls. 21–23.

*1957*c* *Ostrakoden als Salzgehalts-Indikatoren im obern Bathonien des Boulonnais.* Eclogae Geol. Helv., vol. 50, no. 2, pp. 279–283, pl. 1, 3 text-figs.

PINTO, I. D.
1957 – *Secção de Geologia e paleontologia.* Rio Grande do Sul, Univ., Inst. Ciênc. Nat., Relatório do Director (1954–1957), pp. 77–79 (includes the *nomen nudum Bisulcocypris*).

POKORNÝ, V.
1957 – *The Phylomorphogeny of the hinge in Podocopida (Ostracoda, Crustacea) and its bearing on the taxionomy.* Acta Univ., Carolinae, Geologica, 1957, pp. 1–22, 4 text-figs.

PURI, H. S.
1957*a* *Notes on the ostracode subfamily Cytherideidinae Puri, 1952.* Washington Acad. Sci., Jour., vol. 47, no. 9, pp. 305–306.

1957*b* *Postscript notes on the ostracode subfamily Brachycytherinae.* Washington Acad. Sci., Jour., vol. 47, no. 9, pp. 306–308.

1957*c* *Stratigraphy and zonation of the Ocala group; Part III–Ostracoda.* Florida, Geol. Survey, Bull., no. 38, pp. 187–248, pls. 1–15.

1957*d* *Henryhowella, new name for Howella Puri, 1956.* Jour. Pal., vol. 31, no. 5, p. 982.

PURI, H. S., AND HULINGS, N. C.
*1957 – *Recent ostracode facies from Panama City to Florida Bay area.* Gulf Coast Assoc. Geol. Soc., Trans., vol. 7, pp. 167–190, 11 text-figs.

RUGGIERI, G.
1957*a* *Un rappresentante del genere Cuneocythere (Ostracoda, Podocopa) nel Miocene italiano.* Giorn. Geol., ser. 2, vol. 26, pp. 1–6, text-figs. 1–5.

1957*b* *Una terminologia italiana per il carapace degli ostracodi Paleozoici.* Giorn. Geol., ser. 2, vol. 26, pp. 1–8, 5 text-figs.

SOHN, I. G.
*1957 – *Ostracodes of the Post-Paleozoic.* In: *Treatise on marine ecology and paleoecology.* Geol. Soc. Amer., Mem., no. 67, vol. 2, pp. 937–942.

SWAIN, F. M.
1957 – *Early Middle Ordovician Ostracoda of the eastern United States; I–Stratigraphic data and description of Leperditiidae, Aparchitidae and Leperditellidae.* Jour. Pal., vol. 31, no. 3, pp. 528–570, pls. 59–62, 10 text-figs.

SYLVESTER-BRADLEY, P. C.
*1957*a* *Proposed use of the plenary powers to designate for the genus "Indiana" Mathew, 1902 (Class Crustacea, Order Ostracoda) a type species in harmony with accustomed usage.* Bull. Zool. Nomencl., vol. 13, pt. 1, pp. 29–31.
*1957*b* *Amendment of proposals concerning the use of plenary powers in the case of the genus "Indiana" Matthew, 1902 (Class Crustacea, Order Ostracoda).* Bull. Zool. Nomencl., vol. 13, pt. 6, pp. 191–193.

TRIEBEL, E.
1957 – *Neue Ostracoden aus dem Pleistozän von Kalifornien.* Senckenbergiana Lethaea, vol. 38, no. 5/6, pp. 291–309, pls. 1–5.

ULRICH, E. O., AND SWAIN, F. M.
1957 – *See* SWAIN, 1957.

WAGNER, C. W.
1957 – *Sur les ostracodes du Quaternaire récent des Pays-Bas et leur utilisation dans l'étude géologique des dépôts holocènes.* The Hague: Mouton et Cie., pp. 1–259, pls. 1–50, 26 text-figs.

WICHER, C. A.
*1957*a* *Die mikropaläontologische Gliederung des nichtmarinen Keuper.* Erdöl und Kohle, vol. 10, pp. 3–7, pl. 3, 2 text-figs.
*1957*b* *Die Gattung Gomphocythere in Nordwestdeutschland und das Problem der brackischen Ostracoden.* Micropaleontology, vol. 3, no. 3, pp. 269–275, pls. 1–2.

NEW SUBGENERA, GENERA, AND SUPRAGENERIC CATEGORIES IN 1957

In the alphabetically arranged list of genera, the order of the items given in each entry is as follows: Name of the genus, its author and date; in brackets, the name of the type species, its author and date, and its page and figure in the original reference, if previously described (in most cases the full reference for the type species can be found in the CATALOGUE OF OSTRACODA); next, the page and figure of the type species in the reference in which the genus was proposed; in parentheses, the stratigraphic horizon and geographic locality of the type species; then the range and habitat of the genus; and finally the family affiliation of the genus if noted in the paper in which the new genus was described.

Absonocytheropteron Puri, 1957*c* [*A. carinata* Puri, 1957*c*]; p. 204, pl. 14, figs. 9–12; pl. 15, figs. 9–12 (Upper Eocene, Florida); Upper Eocene, marine; Cytheridae, Cytherurinae.

Acanthobolbina Harris, 1957 [*A. loeblichi* Harris, 1957]; p. 223, pl. 9, fig. 13a–b (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Hollinidae.

Actinochilina Jaanusson, 1957 [*Eurychilina suecica* Thorslund, 1948, p. 368, pl. 20, figs. 8–9]; p. 256, pl. 3, fig. 9 (Middle Ordovician, Sweden); Middle Ordovician, marine; Eurychilinidae, Chilobolbininae.

Amphicytherura Butler and Jones, 1957 [*Cytherura? dubia* Israelsky, 1929, p. 6, pl. 4a, fig. 6]; p. 41, pl. 5, fig. 1a–d (Upper Cretaceous, Arkansas); Upper Cretaceous, marine; Cytheridae, Trachyleberinae.

Annosacythere Kuznetsova, 1957 [*A. costaflexuosa* Kuznetsova, 1957]; p. 173, pl. 2, figs. 1–2 (Lower Cretaceous, Caucasus, Russia); Lower Cretaceous, marine; Cytheridae.

Ballardina Harris, 1957 [*B. concentrica* Harris, 1957]; p. 224, pl. 10, fig. 3 (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Hollinidae.

Bisulcocypris Pinto, 1957; p. 78 [*nomen nudum*].

Boldella Keij, 1957 [*B. deldensis* Keij, 1957]; p. 163, pl. 11, figs. 1–2 (Upper Eocene, Netherlands); Upper Eocene (to Miocene?), marine; Cytheridae, Paradoxostominae.

Bosquetina Keij, 1957 [*Cythere pectinata* Bosquet, 1852, p. 113, pl. 6, fig. 1]; p. 118, pl. 15, figs. 11–14 (Pliocene, France); Oligocene to Recent, marine; Cytheridae, Brachycytherinae.

Caspiollina Mandelstam, 1957 [*C. uschakensis* Mandelstam, 1957]; p. 169, pl. 1, figs. 3–4 (Pliocene, Russia); Pliocene, freshwater(?); Cyprididae.

CHILOBOLBININAE Jaanusson, 1957; pp. 233–234; new subfamily of Eurychilinidae, to include: *Chilobolbina* Ulrich and Bassler, 1923; *Coelochilina* Ulrich and Bassler, 1923; *Apatochilina* Ulrich and Bassler, 1923; *Laccochilina (Laccochilina)* Hessland, 1949; *Laccochilina (Prochilina)* Jaanusson, 1957; *Platybolbina* Henningsmoen, 1953; *Cystomatochilina* Jaanusson, 1957; *Actinochilina* Jaanusson, 1957.

Chrissia Hartmann, 1957*c* [*C. levetzovi* Hartmann, 1957*c*]; pp. 50–51, text-figs. 1–4 (Recent, Transvaal, South Africa); Recent, freshwater; Cyprididae, Cypridinae.

Craspedopyxion Jaanusson, 1957 [*Primitia undulosa* Öpik, 1937, p. 80, pl. 1, fig. 1a–b; pl. 6, fig. 1a–b]; pp. 429–430, pl. 15, figs. 9–11, text-fig. 46c (Ordovician, Estonia); Ordovician, marine; Leperditellidae.

Cystomatochilina Jaanusson, 1957 [*Primitia (Ulrichia?) umbonata* Krause, 1892, p. 389, pl. 21, figs. 10–11]; text-fig. 16 (Upper Ordovician, Germany); Upper Ordovician to Silurian(?), marine; Eurychilinidae, Chilobolbininae.

CYTHEROPTERINAE Hanai, 1957*c*; p. 26; new subfamily of Cytheridae to include the following genera: *Cytheropteron* Sars, 1865 (1866); *Aversovalva* Hornibrook, 1952; *Kangarina* Coryell and Fields, 1937; *Kobayashiina* Hanai, 1957*c*.

Dogelinella Schneider, 1957 [*D. taeniata* Schneider, 1957]; p. 167, pl. 1, fig. 8 (Pliocene, Russia?); Pliocene, freshwater(?); Cyprididae.

Echinoprimitia Harris, 1957 [*E. imputata* Harris, 1957]; p. 190, pl. 6, fig. 5a–b (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Primitiidae.

Elofsonia Wagner, 1957 [*Loxoconcha baltica* Hirschmann, 1909, p. 294, figs. 11–12]; p. 71, pl. 31, figs. 1–5 (Recent, Finland); Recent, brackish-water; Cytheridae, Loxoconchinae.

Eobromidella Harris, 1957 [*E. eurychilinoides* Harris, 1957]; p. 238, pl. 8, fig. 1a–b (Middle Ordovician, Oklahoma); Lower and Middle Ordovician, marine; Beyrichiidae.

Eohollina Harris, 1957 [*Beyrichia irregularis* Spivey, 1939, p. 172, pl. 21, figs. 1–2]; p. 207 (Middle Ordovician, Iowa); Ordovician and Silurian, marine; Hollinidae.

Eoprimitia Harris, 1957 [*P. bonnemai* Swartz, 1936, pp. 543, 566, pl. 86, fig. 6]; p. 192 (= *Bonneprimites* Swartz and Whitmore, 1956).

Fergania Mandelstam, 1957 [*F. ferganensis* Mandelstam, 1957]; p. 170, pl. 1, fig. 2 (Lower Cretaceous, Russia?); Lower Cretaceous, freshwater; Cyprididae.

Galliaecytheridea Oertli, 1957*a* [*G. dissimilis* Oertli, 1957*a*]; p. 654, pl. 1, figs. 32–49; pl. 2, figs. 40–44 (Upper Jurassic, France); Upper Jurassic, marine; Cytheridae, Cytherideinae.

Gesa Hartmann, 1957*c* [*G. dubia* Hartmann, 1957*c*]; p. 57, text-figs. 15–21 (Recent, Transvaal, South Africa); Recent, freshwater; Cyprididae, Cypridinae.

Glymmatobolbina Harris, 1957 [*G. quadrata* Harris, 1957]; p. 243, pl. 8, fig. 9a–c (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Kloedenellidae.

Goerlichia Keij, 1957 (new subgenus of *Cyprideis*) [*Cytheridea williamsoniana* Bosquet, 1852, p. 43, pl. 2, fig. 6]; p. 69, pl. 7, figs. 6–8; pl. 18, figs. 18–20 (Oligocene, Belgium); Eocene to Miocene, marine; Cytheridae, Cytherideinae.

Grammolomatella Jaanusson, 1957 [*Biflabellum vestrogothicum* Henningsmoen, 1948, p. 418, pl. 25, fig. 12]; pp. 410–412, pl. 12, figs. 23–25, text-fig. 45 (Upper Ordovician, Sweden); Middle to UpperOrdovician, marine; Hollinidae, Hollininae.

Haplobolbina Harris, 1957 [*H. arcuata* Harris, 1957]; p. 227, pl. 8, fig. 6a–c (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Hollinidae.

Hemicyprinotus Schneider, 1957 [*H. valvaetumidus* Mandelstam, 1957]; p. 167, pl. 1, fig. 6 (Pliocene, China); Pliocene, freshwater; Cyprididae.

Hilseweckella Harris, 1957 [*H. rugulosa* Harris, 1957]; p. 177, pl. 5, fig. 6a–b (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Leperditellidae.

Howeina Hanai, 1957*c* [*Howeina camptocytheroidea* Hanai, 1957*c*]; p. 22, pl. 3, fig. 4a–c, text-fig. 5a–b (Upper Pliocene, Japan); Upper Pliocene, marine; Cytheridae, Cytherurinae.

Hyperchilarina Harris, 1957 [*H. ovata* Harris, 1957]; p. 143, pl. 5, fig. 17a–b (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Leperditellidae.

Jugosocythereis Puri, 1957*c* [*Cythereis bicarinata* Swain, 1946, p. 376, pl. 54, fig. 7a–d; pl. 55, fig. 1a–e]; p. 200, pl. 12, figs. 11–20 (Upper Eocene, Florida); Upper Eocene to Recent, marine; Cytheridae, Trachyleberinae.

Juvenix Kuznetsova, 1957 [*J. pseudocuspidatus* Kuznetsova, 1957]; p. 184, pl. 4, figs. 2–3 (Lower Cretaceous, Caucasus, Russia); Lower Cretaceous, marine; Cytheridae,Cytherinae.

Kayina Harris, 1957 [*K. hybosa* Harris, 1957]; p. 159, pl. 3, fig. 11a–d (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Leperditellidae.

Kingmaina Keij, 1957 [*Cythere forbesiana* Bosquet, 1852, p. 129, pl. 6, fig. 13]; p. 129, pl. 11, figs. 9–10; pl. 14, figs. 8–9 (Lower Eocene, France); Upper Cretaceous to Upper Eocene, marine; incertae sedis.

Kobayashiina Hanai, 1957*c* [*K. hyalinosa* Hanai, 1957*c*]; p. 30, pl. 4, fig. 5a–b, text-fig. 6a–b (Upper Pliocene, Japan); Upper Pliocene, marine; Cytheridae, Cytheropterinae.

Lennukella Jaanusson, 1957 [*Drepanella europaea* Öpik, 1937, p. 54, pl. 3, figs. 11–12; pl. 8, fig. 10a–b; pl. 12, figs. 2–3]; pp. 336–338, pl. 10, fig. 1, text-fig. 34 (Middle Ordovician, Estonia); Middle Ordovician, marine; Bassleratiidae, Bassleratiinae.

Leptocytherinae Hanai, 1957*a*; p. 436; new subfamily of Cytheridae, to include the following genera: *Leptocythere* Sars, 1925; *Callistocythere* Ruggieri, 1953; *Tanella* Kingma, 1948.

Levisulculus Jaanusson, 1957 [*L. lineatus* Jaanusson, 1957]; pp. 320–322, pl. 8, figs. 12–15, text-fig. 26c–d (Middle Ordovician, Sweden); Middle Ordovician, marine; Piretellidae, Tvaerenellinae.

Lomatobolbina Jaanusson, 1957 [*Ctenobolbina mammillata* Thorslund, 1940, p. 174, pl. 2, figs. 8–9]; pp. 395–397, pl. 12, figs. 6–8 (Middle Ordovician, Sweden); Middle and Upper(?) Ordovician, marine; Sigmoopsidae.

Merocythere Oertli, 1957*a* (new subgenus of *Amphicythere* Triebel, 1954 [*Clithrocytheridea plena* Schmidt, 1954; p. 90, pl. 6, fig. 10; pl. 8, figs. 32–34, 35]; p. 676, pl. 7, figs. 227–228 (Upper Jurassic, Germany); Upper Jurassic, marine; Cytheridae.

Metacytheropteron Oertli, 1957*a* [*M. elegans* Oertli, 1957*a*]; p. 664, pl. 4, figs. 116–124 (Upper Jurassic, France); Upper Jurassic to Lower Cretaceous, marine; Cytheridae, Cytherinae.

Naviculina Katz, 1957 [*N. longa* Liubimova, 1957, in Mandelstam and others, 1957]; p. 178, pl. 3, figs. 5–6 (Middle Jurassic, Ukraine, Russia); Middle Jurassic, marine; Cytheridae.

Nereina Mandelstam, 1957 [*N. barenzovensis* Mandelstam, 1957]; p. 179, pl. 3, figs. 7–8 (Recent, Barents Sea); Recent, marine; Cytheridae.

Oecematobolbina Jaanusson, 1957 [*O. nitens* Jaanusson, 1957]; p. 401, pl. 12, figs. 13–19 (Middle Ordovician, Sweden); Middle Ordovician, marine; Sigmoopsidae.

Oepikellinae Jaanusson, 1957; pp. 269–270; new subfamily of Eurychilinidae, to include: *Oepikella* Thorslund, 1940.

Oepikiumidae Jaanusson, 1957; pp. 406–407; new family, to include the genus *Oepikium* Agnew, 1942.

Paegnium Kesling, 1957*b* [*P. tanaum* Kesling, 1957*b*]; pp. 22–23, pl. 1, figs. 1–12 (Middle Devonian, New York); Middle Devonian, marine.

Paenula Kuznetsova, 1957 [*P. superba* Kuznetsova, 1957]; p. 176, pl. 2, fig. 6 (Lower Cretaceous, Caucasus, Russia); Lower Cretaceous, marine; Cytheridae.

Paijenborchellina Kuznetsova, 1957 [*P. excelens* Kuznetsova, 1957]; p. 180, pl. 4, figs. 4–5 (Lower Cretaceous, Caucasus, Russia); Lower Cretaceous, marine; Cytheridae.

Paracyprinotus Schneider, 1957 [*P. similis* Schneider, 1957]; p. 171, pl. 1, fig. 5 (Pliocene, Asia); Pliocene, freshwater(?); Cypridae.

Paracytherideinae Puri, 1957*c*; p. 191; new subfamily of Cytheridae, to include the genera: *Paracytheridea* Müller, 1894, and *Paracytheropteron* Ruggieri, 1952.

Paraeucypris Schneider, 1957 [*P. tota* Schneider, 1957]; p. 172, pl. 1, fig. 7 (Pliocene, Russia?); Pliocene, freshwater(?); Cyprididae.

Parapyxion Jaanusson, 1957 [*Primitia subovata* Thorslund, 1948, p. 365, pl. 20, fig. 5]; pp. 423–425, pl. 15, figs. 16–19, text-fig. 46a (Middle Ordovician, Sweden); Middle to Upper Ordovician, marine; Leperditellidae.

Pavloviella Kuznetsova, 1957 [*P. barremica* Kuznetsova, 1957]; p. 174, pl. 2, fig. 3 (Lower Cretaceous, Caucasus, Russia); Lower Cretaceous, marine; Cytheridae.

Pectocythere Hanai, 1957*b* [*P. quadrangulata* Hanai, 1957*b*]; p. 474, pl. 11, fig. 3a–b, text-fig. 6a–b (Upper Pliocene, Japan); Upper Pliocene, marine; Cytheridae, Pectocytherinae.

Pectocytherinae Hanai, 1957*b*; p. 471; new subfamily of Cytheridae, to include the following genera: *Pectocythere* Hanai, 1957*b*; *Munseyella* van den Bold, 1957; *Arcacythere* Hornibrook, 1953.

Pericythere Hartmann, 1957*a* [*P. foveata* Hartmann, 1957*a*]; p. 146, pl. 43, figs. 62–66; pl. 45, figs. 67–74 (Recent, El Salvador); Recent, marine; Cytheridae, Cytherinae.

Piretia Jaanusson, 1957 [*P. geniculata* Jaanusson, 1957]; p. 282, pl. 4, figs. 21–22, text-fig. 21b (Lower Ordovician, Sweden); Lower Ordovician, marine; Piretellidae, Piretellinae.

Platycypris Herbst, 1957 [*Platycypris baueri* Herbst, 1957]; pp. 224–225, text-figs. 1–19 (Recent, Australia); Recent, freshwater; Cyprididae, Cypridinae.

Platyrhomboides Harris, 1957 [*P. quadratus* Harris, 1957]; p. 256, pl. 10, fig. 4a–c (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Beecherellidae.

Prochilina Jaanusson, 1957; new subgenus of *Laccochilina* [*Primitia decumana* Bonnema, 1909, pp. 26–27, pl. 2, figs. 10–14]; p. 250, pl. 2, figs. 15–16; pl. 3, figs. 1–4, text-figs. 14c–d, 15 (Middle Ordovician, Sweden); Middle Ordovician, marine; Eurychilinidae, Chilobolbininae.

Protallinella Jaanusson, 1957 [*Beyrichia grewingki* Bock, 1867, p. 594]; pp. 353–354 (Middle Ordovician, Russia); Middle Ordovician, marine; Bassleratiidae, Quadrijugatorinae.

Pseudocytheromorpha Puri, 1957*c* [*P. elongata* Puri, 1957*c*]; p. 198, pl. 14, figs. 1–8 (Upper Eocene, Florida); Upper Eocene, marine; Cytheridae, Trachyleberinae.

Pseudoeucypris Schneider, 1957 [*P. eboris* Schneider, 1957]; p. 171, pl. 1, fig. 1 (Pliocene, Russia); Pliocene, freshwater; Cyprididae.

PTERYGOCYTHERINAE Puri, 1957*b*; p. 307; new subfamily of Trachyleberidae, to include the genera: *Pterygocythereis* Blake, 1933, and *Alatacythere* Murray and Hussey, 1942.

Pulviella Schneider, 1957 [*P. ovalis* Schneider, 1957]; p. 181, pl. 3, fig. 3 (Lower Triassic, Emba oil fields, Russia); Lower Triassic, marine; Cytheridae.

Renngartenella Schneider, 1957 [*R. pennata* Schneider, 1957]; p. 182, pl. 3, fig. 4; pl. 4, fig. 6 (Lower Triassic, Russia); Lower Triassic, marine; Cytheridae.

Rubracea Mandelstam, 1957 [*R. artis* Liubimova, 1957, in Mandelstam and others, 1957]; p. 177, pl. 3, figs. 1–2 (Upper Jurassic, Russia?); Upper Jurassic, marine; Cytheridae.

Ruggieria Keij, 1957 [*Cythere micheliniana* Bosquet, 1852, p. 111, pl. 5, fig. 13]; p. 112, pl. 15, figs. 5–6; pl. 20, figs. 1–3 (Miocene, France); Miocene to Recent, marine; Cytheridae, Trachyleberidinae.

Segmina Mandelstam, 1957 [*Cytheropteron lunulare* Lienenklaus, 1894, p. 247, pl. 17, fig. 6]; p. 177, pl. 2, fig. 7; pl. 3, fig. 9 (Cretaceous, Caucasus, Russia); Cretaceous, marine; Cytheridae.

Semicytherura Wagner, 1957 [*Cythere nigrescens* Baird, 1838, p. 143, pl. 5, fig. 27]; p. 80, pl. 37, figs. 1–5 (Recent, England); Pleistocene to Recent, marine; Cytheridae, Cytherurinae.

Stillina Laurencich, 1957 (*S. asterata* Laurencich, 1957]; p. 455, text-fig. 1 (Lower Cretaceous, Texas); Lower Cretaceous, marine; Cytherurinae.

Subulacypris Schneider, 1957 [*S. subtilis* Schneider, 1957]; p. 168, pl. 1, fig. 9 (Pliocene, China); Pliocene, freshwater(?); Cyprididae.

Tallinnellina Jaanusson, 1957 [*Tetradella teres* Hessland, 1949, p. 348, pl. 9, figs. 12, 14–16, 18, 19]; pp. 354–355, pl. 10, figs. 2, 4, text-fig. 35c (Lower Ordovician, Sweden); Lower Ordovician, marine; Bassleratiidae, Quadrijugatorinae.

Taxodiella Kuznetsova, 1957 [*T. fiscellaformis* Kuznetsova, 1957]; p. 174, pl. 2, fig. 4 (Lower Cretaceous, Caucasus, Russia); Lower Cretaceous, marine; Cytheridae.

Tetradellina Harris, 1957 [*T. henningsmoeni* Harris, 1957]; p. 250, pl. 8, fig. 14a–b (Middle Ordovician, Oklahoma); Middle Ordovician, marine; Tetradellidae.

Thalassocypria Hartmann, 1957*a* [*T. aestuarina* Hartmann, 1957*a*]; p. 135, pl. 39, figs. 1–11; pl. 40, figs. 12–16 (Recent, El Salvador); Recent, marine; Cyprididae.

Tvaerenella Jaanusson, 1957 [*Primitiella carinata* Thorslund, 1940, p. 163, pl. 4, fig. 8]; p. 296, pl. 6, figs. 4–9, text-fig. 26a–b (Middle Ordovician, Sweden); Middle to Upper Ordovician, marine; Piretellidae, Tvaerenellinae.

TVAERENELLINAE Jaanusson, 1957; pp. 294–296; new subfamily of Piretellidae, to include: *Dicranella* Ulrich, 1894; ?*Ectoprimitia* Bouček, 1936; *Hesperidella* Öpik, 1937; *Euprimites* Hessland, 1949; *Tvaerenella* Jaanusson, 1957; *Levisulculus* Jaanusson, 1957.

Veenia Butler and Jones, 1957 [*Cythereis ozanana* Israelsky, 1929, p. 13, pl. 3a, figs. 1–3]; p. 43, pl. 3, fig. 4a–e (Upper Cretaceous, Arkansas); Upper Cretaceous, marine; Cytheridae, Trachyleberinae.

Velarocythere Brown, 1957 [*V. scuffeltonensis* Brown, 1957]; p. 20, pl. 5, figs. 5–9 (Upper Cretaceous, North Carolina); Upper Cretaceous, marine; Cytheridae.

Vernoniella Oertli, 1957*a* [*V. sequana* Oertli, 1957*a*]; p. 659, pl. 3, figs. 70–85 (Upper Jurassic, France); Upper Jurassic, marine; Cytheridae, Cytherideinae.

Vicinia Kuznetsova, 1957 [*V. sutilis* Kuznetsova, 1957]; p. 183, pl. 4, fig. 1 (Lower Cretaceous, Caucasus, Russia); Lower Cretaceous, marine; Cytheridae.

NEW SPECIES, SUBSPECIES, AND VARIETIES IN 1957

Absonocytheropteron carinata Puri, 1957*c*; p. 205, pl. 14, figs. 9–12; pl. 15, figs. 9–12 (Upper Eocene, Florida); Cytheridae, Cytherurinae.

Acanthobolbina loeblichi Harris, 1957; p. 223, pl. 9, fig. 13a–b (Middle Ordovician, Oklahoma); Hollinidae.

Aglaiocypris enigmatica Keij, 1957; p. 50, pl. 7, figs. 19–21 (Middle Eocene, France); Cyprididae, Cypridinae.

Amphicythere (Amphicythere?) confundens Oertli, 1957; p. 674, pl. 7, figs. 219–226 (Upper Jurassic, France); Cytheridae.

Annosacythere costaflexuosa Kuznetsova, 1957; p. 173, pl. 2, figs. 1–2 (Lower Cretaceous, Caucasus, Russia); Cytheridae.

Aparchites kauffmanensis Swain, 1957; p. 560, pl. 61, fig. 11; pl. 62, fig. 9 (Middle Ordovician, Pennsylvania); Aparchitidae.

Aparchites pembertonensis Swain, 1957; p. 560, pl. 61, fig. 12a–b; pl. 62, fig. 11 (Middle Ordovician, Pennsylvania); Aparchitidae.

Argilloecia jeurrensis Keij, 1957; p. 49, pl. 1, figs. 12–14 (Oligocene, France); Cyprididae, Pontocypridinae.

Aulocytheridea diegemensis Keij, 1957; p. 64, pl. 4, fig. 15; pl. 5, figs. 12–14 (Middle Eocene, Belgium); Cytheridae, Cytherideinae.

Aulocytheridea mourloni Keij, 1957; p. 66, pl. 4, fig. 1; pl. 5, figs. 9–11 (Upper Eocene, Belgium); Cytheridae, Cytherideinae.

Aulocytheridea punctatella Keij, 1957; p. 67, pl. 4, fig. 18; pl. 5, figs. 6–8 (Upper Eocene, Belgium); Cytheridae, Cytherideinae.

Aulocytheridea tavernieri Keij, 1957; p. 68, pl. 6, fig. 3 (Upper Eocene, Belgium); Cytheridae, Cytherideinae.

Bairdia dolicha van den Bold, 1957*a*; p. 5, pl. 2, fig. 2a–b (Paleocene, Trinidad); Bairdiidae.

Bairdia exoura van den Bold, 1957*a*; p. 6, pl. 2, fig. 6 (Paleocene, Trinidad); Bairdiidae.

Bairdia ocalana Puri, 1957*c*; p. 189, pl. 1, figs. 1–5 (Upper Eocene, Florida); Bairdiidae.

Bairdia nagappai Puri, 1957*c*; p. 189, pl. 1, figs. 6–9 (Upper Eocene, Florida); Bairdiidae.

Bairdia pittensis Brown, 1957; p. 10, pl. 3, figs. 1–3 (Upper Cretaceous, North Carolina); Bairdiidae.

Bairdia soldadensis van den Bold, 1957*a*; p. 6, pl. 2, fig. 3a–b (Paleocene, Trinidad); Bairdiidae.

Bairdoppilata gliberti Keij, 1957; p. 53, pl. 1, figs. 18–21 (Middle Eocene, France); Bairdiidae.

Ballardina concentrica Harris, 1957; p. 225, pl. 10, fig. 3 (Middle Ordovician, Oklahoma); Hollinidae.

Ballardina minuta Harris, 1957; p. 226, pl. 10, fig. 1 (Middle Ordovician, Oklahoma); Hollinidae.

Ballardina simplex Harris, 1957; p. 226, pl. 9, fig. 16; pl. 10, fig. 2 (Middle Ordovician, Oklahoma); Hollinidae.

Balticella deckeri subsp. *elongata* Harris, 1957, new subsp.; p. 242, pl. 8, fig. 8 (Middle Ordovician, Oklahoma); Kloedenellidae.

Bassleratia corrugata Harris, 1957; p. 250, pl. 8, fig. 13a–b (Middle Ordovician, Oklahoma); Tetradellidae.

Bellornatia mclishi Harris, 1957; p. 211, pl. 7, fig. 4a–b (Middle Ordovician, Oklahoma); Hollinidae.

Boldella deldenensis Keij, 1957; p. 163, pl. 11, figs. 1–2 (Upper Eocene, Netherlands); Cytheridae, Paradoxostominae.

Brachycythere gigantea Puri, 1957*c*; p. 192, pl. 4, figs. 1–6; pl. 5, figs. 1–8 (Upper Eocene, Florida); Cytheridae, Brachycytherinae.

Brachycythere? kugleri van den Bold, 1957*a*; p. 10, pl. 4, fig. 7a–b (Paleocene, Trinidad); Cytheridae, Brachycytherinae.

Brachycythere? kugleri subsp. *soldadensis* van den Bold, 1957*a*, new subsp.; p. 10, pl. 4, fig. 8a–b (Paleocene, Trinidad); Cytheridae, Brachycytherinae.

Brachycythere maerkyi van den Bold, 1957*a*; p. 10, pl. 3, fig. 8a–b (Paleocene, Trinidad); Cytheridae, Brachycytherinae.

Brachycythere nalinnesensis Keij, 1957; p. 120, pl. 11, figs. 7–8 (Middle Eocene, Belgium); Cytheridae, Brachycytherinae.

Brachycythere raleighensis Brown, 1957; p. 13, pl. 4, figs. 11–13 (Upper Cretaceous, North Carolina); Cytheridae.

Bradleya kaasschieteri Keij, 1957; p. 99, pl. 16, figs. 12–13; pl. 19, fig. 13–14 (Upper Eocene, Belgium); Cytheridae, Trachyleberidinae.

Bradycypris rotunda Grékoff, 1957; p. 37, pl. 1, figs. 1–4, text-fig. 5 (Lower Cretaceous, Belgian Congo); Cyprididae, Cypridinae.

Briartina extenta Ulrich and Swain, 1957; p. 550, pl. 59, fig. 11a–b (Middle Ordovician, Ontario, Canada); Leperditiidae, Leperditiinae.

Briartina modesta Ulrich and Swain, 1957; p. 550, pl. 59, fig. 12 (Middle Ordovician, Kentucky); Leperditiidae, Leperditiinae.

Bromidella spiveyi Harris, 1957; p. 237, pl. 8, fig. 2 (Middle Ordovician, Oklahoma); Beyrichiidae.

Bythocypris windhami Butler and Jones, 1957; p. 12, pl. 1, fig. 8a–e (Upper Cretaceous, Louisiana); Bairdiidae, Bairdiinae.

Bythocypris? spinosa Harris, 1957; p. 260, pl. 10, fig. 14a–c (Middle Ordovician, Oklahoma); Bairdiidae.

Bythocypris cuisensis Keij, 1957; p. 55, pl. 2, figs. 3–6 (Lower Eocene, France); Bairdiidae.

Bythocypris guppyi van den Bold, 1957*a*; p. 6, pl. 2, fig. 9 (Paleocene, Trinidad); Bairdiidae.

Callistocythere alata Hanai, 1957*a*; p. 450, pl. 7, fig. 4a–b; pl. 10, fig. 5 (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere hayamensis Hanai, 1957*a*; p. 453, pl. 7, fig. 2a–d (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere japonica Hanai, 1957*a*; p. 457, pl. 9, fig. 2a–g, text-figs. 1b–c, 2e–f (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere japonica uranipponica Hanai, 1957*a*, n. subsp.; p. 459, pl. 9, fig. 3a–c (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere minor Hanai, 1957*a*; p. 461, pl. 10, fig. 1a–e, text-fig. 2a–b (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere nipponica Hanai, 1957*a*; p. 446, pl. 7, fig. 1a–b; pl. 10, fig. 4, text-figs. 1a, 2c–d (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere pumila Hanai, 1957*a*; p. 459, pl. 10, fig. 2a–c (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere reticulata Hanai, 1957*a*; p. 448, pl. 8, fig. 2a–d (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere rugosa Hanai, 1957*a*; p. 451, pl. 8, fig. 3a–d (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere setanensis Hanai, 1957*a*; p. 457, pl. 10, fig. 3a–b (Upper Pliocene, Japan); Cytheridae, Leptocytherinae.

Callistocythere subjaponica Hanai, 1957*a*; p. 455, pl. 8, fig. 4a–e (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere undata Hanai, 1957*a*; p. 452, pl. 8, fig. 1a–d (Recent, Japan); Cytheridae, Leptocytherinae.

Callistocythere undulatifacialis Hanai, 1957*a*; p. 455, pl. 7, fig. 3a–d; pl. 10, fig. 6 (Recent, Japan); Cytheridae, Leptocytherinae.

Campylocythere striata van den Bold, 1957*b*; p. 237, pl. 3, fig. 2a–d (Oligo-Miocene, Trinidad); Cytheridae, Cytherinae.

Caspiocypris intestina Schneider, 1957; p. 169 (age uncertain; Ukraine, Russia); Cyprididae.

Caspiollina uschokensis Mandelstam, 1957; p. 170, pl. 1, figs. 3–4 (Pliocene, Russia); Cyprididae.

Chilobolbina lativelata Jaanusson, 1957; p. 240, pl. 1, figs. 8–11 (Lower to Middle Ordovician, Sweden); Eurychilinidae, Chilobolbininae.

Chilobolbina sudermannica Jaanusson, 1957; p. 238, pl. 1, figs. 1–5, text-figs. 11b, 13 (Middle Ordovician, Sweden); Eurychilinidae, Chilobolbininae.

Chrissia levetzori Hartmannn, 1957*c*; p. 51, text-figs. 1–4 (Recent, Transvaal, South Africa); Cyprididae, Cypridinae.

Clithrocytheridea lerichei Keij, 1957; p. 58, pl. 3, figs. 4–7; pl. 4, fig. 2 (Middle Eocene, France); Cytheridae, Cytherideinae.

Clithrocytheridea reticulata van den Bold, 1957*b*; p. 236, pl. 4, fig. 3a–c (Miocene, Trinidad); Cytheridae, Cytherideinae.

Coelochilina alata Harris, 1957; p. 240, pl. 8, fig. 4a–c (Middle Ordovician, Oklahoma); Beyrichiidae.

Coelochilina alatispinata Harris, 1957; p. 240, pl. 8, fig. 5a–b (Middle Ordovician, Oklahoma); Beyrichiidae.

Conchoprimites ovoides Swain, 1957; p. 569, pl. 62, figs. 22–23 (Middle Ordovician, New York); Leperditellidae.

Conchoprimitia oepikana Swain, 1957; p. 568, pl. 62, fig. 26a–b (Middle Ordovician, New York); Leperditellidae.

Costa santacrucensis van den Bold, 1957*b*; p. 241, pl. 2, fig. 5a–b Miocene, Trinidad); Cytheridae, Cytherinae.

Cryptophyllus gibbosum Harris, 1957; p. 180, pl. 5, figs. 7a–c, 8, 9a–c (Middle Ordovician, Oklahoma); Leperditellidae.

Cryptophyllus nuculopsis Harris, 1957; p. 182, pl. 5, fig. 11a–b (Middle Ordovician, Oklahoma); Leperditellidae.

Ctenobolbina abrupta Harris, 1957; p. 213, pl. 8, figs. 18a–b, 19–20 (Middle Ordovician, Oklahoma); Hollinidae.

Ctenobolbina bispinata Harris, 1957; p. 214, pl. 9, fig. 1a–b (Middle Ordovician, Oklahoma); Hollinidae.

Ctenobolbina cancellata Harris, 1957; p. 214, pl. 9, fig. 2a–b (Middle Ordovician, Oklahoma); Hollinidae.

Ctenobolbina cancellata subsp. *varicata* Harris, 1957, new subsp.; p. 215, pl. 9, fig. 3a–b (Middle Ordovician, Oklahoma); Hollinidae.

Ctenobolbina inflata Harris, 1957; p. 216, pl. 9, fig. 6a–b (Middle Ordovician, Oklahoma); Hollinidae.

Ctenobolbina parva Harris, 1957; p. 217, pl. 9, fig. 5a–c (Middle Ordovician, Oklahoma); Hollinidae.

Ctenobolbina percarinata Harris, 1957; p. 218, pl. 9, fig. 7a–b (Middle Ordovician, Oklahoma); Hollinidae.

Ctenobolbina projecta Harris, 1957; p. 218, pl. 9, fig. 8a–b (Middle Ordovician, Oklahoma); Hollinidae.

Cuneocythere ariminensis Ruggieri, 1957*a*; p. 3, text-figs. 1–5 (Miocene, Tortonian; Italy).

Cuneocythere (Cuneocythere) lienenklausi Keij, 1957; p. 74, pl. 9, figs. 12–16 (Middle Oligocene, Belgium); Cytheridae, Cytherideinae.

Cuneocythere (Monsmirabilia) triebeli Keij, 1957; p. 79, pl. 9, figs. 1–4 (Lower Eocene, Belgium); Cytheridae, Cytherideinae.

Cushmanidea? gunteri Puri, 1957*c*; p. 193, pl. 6, figs. 4–5, 7–8 (Upper Eocene, Florida); Cytheridae, Neocytherideidinae.

Cushmanidea laevigata Puri, 1957*c*; p. 194, pl. 6, figs. 9–12 (Upper Eocene, Florida); Cytheridae, Neocytherideidinae.

Cytherura gerlachi Hartmann, 1957*d*; p. 215, text-figs. 21–25 (Recent, Brazil); Cytheridae, Cytherurinae.
Cytherura glossensis Brown, 1957; p. 25, pl. 6, figs. 18–19 (Upper Cretaceous, North Carolina); Cytheridae.
Cytherura leptocytheroidea Hanai, 1957*c*; p. 21, pl. 3, fig. 2a–b (Upper Pliocene, Japan); Cytheridae, Cytherurinae.
Cytherura miurensis Hanai, 1957*c*; p. 18, pl. 2, fig. 4a–b, text-fig. 4a–b (Recent, Japan); Cytheridae, Cytherurinae.
Cytherura oedelemensis Keij, 1957; p. 147, pl. 23, figs. 11–13 (Upper Eocene, Belgium); Cytheridae, Cytherurinae.
Cytherura ostiicola Hartmann, 1957*a*; p. 154, pl. 47, fig. 104; pl. 48, figs. 96–97, 99–101, 103 (Recent, El Salvador); Cytheridae, Cytherurinae.
Cytherura palacii Hartmann, 1957*a*; p. 151, pl. 46, figs. 85–89; pl. 47, figs. 90–95; pl. 153, figs. 98, 102 (Recent, El Salvador); Cytheridae, Cytherurinae.
Cytherura quadrata Hanai, 1957*c*; p. 20, pl. 3, fig. 1a–b, text-fig. 2a–b (Recent, Japan); Cytheridae, Cytherurinae.
Cytherura skippa Hanai, 1957*c*; p. 19, pl. 2, fig. 6a–b (Recent, Japan); Cytheridae, Cytherurinae.
Cytherura subundata Hanai, 1957*c*; p. 20, pl. 3, fig. 3a–d, text-fig. 2a–b (Upper Pliocene, Japan); Cytheridae, Cytherurinae.
Cytherura tetragona Hanai, 1957*c*; p. 18, pl. 2, fig. 5a–b (Recent, Japan); Cytheridae, Cytherurinae.
Dicranella fragilis Harris, 1957; p. 229, pl. 7, figs. 5–6 (Middle Ordovician, Oklahoma); Beyrichiidae.
Dogelinella taeniata Schneider, 1957; p. 168, pl. 1, fig. 8 (Pliocene, Russia?); Cyprididae.
Dolerocypris inflexa Grékoff, 1957; p. 38, pl. 1, figs. 5–6 (Lower Cretaceous, Belgian Congo); Cyprididae, Cypridinae.
Echinocythereis nuda Puri, 1957*c*; p. 197, pl. 9, figs. 5–8 (Upper Eocene, Florida); Cytheridae, Trachyleberinae.
Echinoprimitia imputata Harris, 1957; p. 191, pl. 6, fig. 5a–b (Middle Ordovician, Oklahoma); Primitiidae.
Ectoprimitia pustulosa Swain, 1957; p. 568, pl. 62, fig. 18a–b (Middle Ordovician, New York); Leperditellidae.
Elofsonella salvadoriana Hartmann, 1957*a*; p. 149, pl. 45, figs. 75–78; pl. 46, figs. 79–84 (Recent, El Salvador); Trachyleberidae, Hemicytherinae.
Eobromidella eurychilinoides Harris, 1957; p. 238, pl. 8, fig. 1a–b (Middle Ordovician, Oklahoma); Beyrichiidae.
Eohollina depressa papillata Harris, 1957, new subsp.; p. 209, pl. 7, fig. 3a–b (Middle Ordovician, Oklahoma); Hollinidae.
Eoleperditia abrupta Harris, 1957; p. 128, pl. 1, fig. 5a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoleperditia inflativentralis Harris, 1957; p. 130, pl. 1, fig. 2a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoleperditia magna Harris, 1957; p. 131, pl. 1, fig. 3a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoleperditia mediumbonata Harris, 1957; p. 132, pl. 1, fig. 4a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoleperditia mediumbonata debilis Harris, 1957, n. subsp.; p. 133, pl. 1, fig. 6a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoleperditia? obesiporosa Harris, 1957; p. 133, pl. 1, fig. 7a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoleperditia? perplexa Harris, 1957; p. 134, pl. 1, fig. 8a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoleperditia simplex Harris, 1957; p. 135, pl. 1, fig. 9a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoleperditia spicata Harris, 1957; p. 136, pl. 1, fig. 10a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoleperditia subcarinata Harris, 1957; p. 137, pl. 1, fig. 11a–b (Middle Ordovician, Oklahoma); Leperditiidae.
Eoprimitia arcuata Harris, 1957; p. 193, pl. 6, fig. 6a–b (Middle Ordovicia, Oklahoma); Primitiidae (= *Bonneprimites*).
Eoprimitia cooperi Harris, 1957; p. 194, pl. 6, figs. 10a–b, 11a–c (Middle Ordovician, Oklahoma); Primitiidae (= *Bonneprimites*).
Eoprimitia moorei Harris, 1957; p. 195, pl. 6, fig. 7a–c (Middle Ordovician, Oklahoma); Primitiidae (= *Bonneprimites*).
Eoprimitia quadrata Harris, 1957; p. 196, pl. 6, figs. 8, 9a–b (Middle Ordovician, Oklahoma); Primitiidae (= *Bonneprimites*).
Eoprimitia? subnodosa Harris, 1957; p. 197, pl. 6, fig. 12 (Middle Ordovician, Oklahoma); Primitiidae (= *Bonneprimites*).
Eucytherura hyonensis Keij, 1957; p. 151, pl. 23, figs. 1–3 (Lower Eocene, Belgium); Cytheridae, Cytherurinae.
Euprimites bursellus Jaanusson, 1957; p. 310, pl. 7, figs. 16–20, text-fig. 27e (Middle Ordovician, Sweden); Piretellidae, Tvaerenellinae.
Euprimites effusus Jaanusson, 1957; p. 303, pl. 6, figs. 10–16, text-figs. 5b, 27a, 28–29 (Middle Ordovician, Sweden); Piretellidae, Tvaerenellinae.
Euprimitia elegans Harris, 1957; p. 198, pl. 6, fig. 13a–b (Middle Ordovician, Oklahoma); Primitiidae.
Euprimitia macropuncta Swain, 1957; p. 566, pl. 62, fig. 14 (Middle Ordovician, New York); Leperditellidae.
Euprimitia millepunctata Swain, 1957; p. 566, pl. 62, figs. 20–21 (Middle Ordovician, New York); Leperditellidae.
Euprimitia simplex Swain, 1957; p. 566, pl. 62, fig. 12a–b (Middle Ordovician, New York); Leperditellidae.
Eurychilina cultrata Harris, 1957; p. 231, pl. 7, fig. 11a–b (Middle Ordovician, Oklahoma); Beyrichiidae.
Eurychilina papillata Harris, 1957; p. 232, pl. 7, figs. 9, 10a–b (Middle Ordovician, Oklahoma); Beyrichiidae.
Eurychilina simplex Harris, 1957; p. 232, pl. 7, fig. 13a–b (Middle Ordovician, Oklahoma); Beyrichiidae.
Fergania ferganensis Mandelstam, 1957; p. 170, pl. 1, fig. 2 (Lower Cretaceous, Russia?); Cyprididae.
Galliaecytheridea dissimilis Oertli, 1957*a*; p. 655, pl. 1, figs. 32–49; pl. 2, figs. 40–44 (Upper Jurassic, France); Cytheridae Cytherideinae.
Galliaecytheridea postrotunda Oertli, 1957*a*; p. 656, pl. 2, figs. 45–55 (Upper Jurassic, France); Cytheridae, Cytherideinae.
Gesa dubia Hartmann, 1957*c*; p. 57, text-figs. 15–21 (Recent, Transvaal, South Africa); Cyprididae, Cypridinae.
Glymmatobolbina quadrata Harris, 1957; p. 243, pl. 8, fig. 9a–c (Middle Ordovician, Oklahoma); Kloedenellidae.
Haplobolbina arcuata Harris, 1957; p. 228, pl. 8, fig. 6a–c (Middle Ordovician, Oklahoma); Hollinidae.
Haplocytheridea heizelensis Keij, 1957; p. 61, pl. 5, figs. 18–20 (Upper Eocene, Belgium); Cytheridae, Cytherideinae.
Haplocytheridea heinzelini Keij, 1957; p. 60, pl. 2, figs. 14–15; pl. 5, figs. 15–17 (Upper Eocene, Belgium); Cytheridae, Cytherideinae.
Haplocytheridea? rayburnensis Butler and Jones, 1957; p. 15, pl. 4, fig. 7a–e (Upper Cretaceous, Louisiana); Cytheridae, Cytherideinae.
Haploprimitia angusta Harris, 1957; p. 189, pl. 6, fig. 3a–b (Middle Ordovician, Oklahoma); Primitiidae.
Haploprimitia angusta deltata Harris, 1957, n. var.; p. 190, pl. 6, fig. 4a–b (Middle Ordovician, Oklahoma); Primitiidae.
Hemicyprinotus valvaetumidus Mandelstam, 1957; p. 167, pl. 1, fig. 6 (Pliocene, China); Cyprididae.
Hemicythere crystalriverensis Puri, 1957*c*; p. 202, pl. 13, figs. 21–24 (Upper Eocene, Florida); Cytheridae, Hemicytherinae.
Hemicythere polkensis Puri, 1957*c*; p. 202, pl. 13, figs. 17–20 (Upper Eocene, Florida); Cytheridae, Hemicytherinae.
Hemicythere punctata Puri, 1957*c*; p. 203, pl. 13, figs. 1–8; pl. 15, figs. 1–4 (Upper Eocene, Florida); Cytheridae, Hemicytherinae.

Hemicythere sculpturata Puri, 1957*c*; p. 203, pl. 13, figs. 9–16 (Upper Eocene, Florida); Cytheridae, Hemicytherinae.
Hemicytherideis grosjeani Keij, 1957; p. 81, pl. 7, figs. 3–5 (Middle Eocene, Belgium); Cytheridae, Cytherideidinae.
Hemicytherura cuneata Hanai, 1957*c*; p. 24, pl. 2, fig. 2a–b, text-fig. 1a–b (Recent, Japan); Cytheridae, Cytherurinae.
Hemicytherura kajiyamai Hanai, 1957*c*; p. 24, pl. 2, fig. 1a–d (Miocene to Recent, Japan); Cytheridae, Cytherurinae.
Hemicytherura tricarinata Hanai, 1957*c*; p. 25, pl. 2, fig. 3a–b (Recent, Japan); Cytheridae, Cytherurinae.
Hermanites? grimsdalei van den Bold, 1957*a*; p. 10, pl. 3, fig. 7a–b (Paleocene, Trinidad); Cytheridae, Hemicytherinae.
Hermanites hutchisoni van den Bold, 1957*b*; p. 240, pl. 3, fig. 1a–b (Oligo-Miocene, Trinidad); Cytheridae, Cytherinae.
Hermanites paijenborchiana Keij, 1957; p. 110, pl. 17, figs. 11–14; pl. 21, figs. 10–11 (Middle Eocene, France); Cytheridae, Trachyleberidinae.
Heterochilina ventricornis Ulrich and Swain, 1957; p. 550, pl. 59, fig. 15a–c (Middle Ordovician, Ottawa, Canada); Leperditiidae, Leperditiinae.
Hilseweckella rugulosa Harris, 1957; p. 178, pl. 5, fig. 6a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Hirsutocythere spinosa Puri, 1957*c*; p. 197, pl. 9, fig. 9; pl. 11, figs. 1–8 (Upper Eocene, Florida); Cytheridae, Trachyleberinae.
Hogmochilina coloradoensis Ulrich and Swain, 1957; p. 557, pl. 61, figs. 2, 3a–b (Middle Ordovician, Colorado); Leperditiidae, Isochilininae.
Howeina camptocytheroidea Hanai, 1957*c*; p. 22, pl. 3, fig. 4a–c, text-fig. 5a–b (Upper Pliocene, Japan); Cytheridae, Cytherurinae.
Hyperchilarina angularis Harris, 1957; p. 145 (Middle Ordovician, Oklahoma); Leperditellidae.
Hyperchilarina nodosimarginata Harris, 1957; p. 144, pl. 5, fig. 16a–c (Middle Ordovician, Oklahoma); Leperditellidae.
Hyperchilarina ovata Harris, 1957; p. 145, pl. 5, fig. 17a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Hyperchilarina symmetrica Harris, 1957; p. 147, pl. 5, fig. 18a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Iliocythere costata Hartmann, 1957*d*, p. 209; text-figs. 1–8 (Recent, Brazil); Cytheridae, Cytherinae.
Iliocythere dentato-marginata Hartmann, 1957*a*; p. 142, pl. 42, figs. 41–44; pl. 43, figs. 45–52 (Recent, El Salvador); Cytheridae, Cytherinae.
Iliocythere punctata Hartmann, 1957*a*; p. 144, pl. 41, figs. 35, 42, 53–54; pl. 44, figs. 55–56, 58–60 (Recent, El Salvador); Cytheridae, Cytherinae.
Ilyocypris? compressa Grékoff, 1957; p. 48, pl. 2, figs. 28–29, text-fig. 12 (Lower Cretaceous, Belgian Congo); Cyprididae, Ilyocypridinae.
Ilyocypris minor Grékoff, 1957; p. 46, pl. 2, figs. 26–27, text-fig. 11 (Lower Cretaceous, Belgian Congo); Cyprididae, Ilyocypridinae.
Isochilina mimica Ulrich and Swain, 1957; p. 553, pl. 60, fig. 7 (Middle Ordovician, Tennessee); Leperditiidae, Isochilininae.
Isochilina signifera Ulrich and Swain, 1957; p. 556, pl. 61, fig. 8a–b (Middle Ordovician, Pennsylvania); Leperditiidae, Isochilininae.
Jugosocythereis tricarinata Puri, 1957*c*; p. 201, pl. 12, figs. 1–10 (Upper Eocene, Florida); Cytheridae, Trachyleberinae.
Juvenix pseudocuspidatus Kuznetsova, 1957; p. 184, pl. 4, figs. 2–3 (Lower Cretaceous, Caucasus, Russia); Cytheridae.
Kayina hybosa Harris, 1957; p. 160, pl. 3, fig. 11a–d (Middle Ordovician, Oklahoma); Leperditellidae.
Kayina? porosa Harris, 1957; p. 160, pl. 3, fig. 12a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Klieana levis Oertli, 1957*b*; p. 760, pl. 22, figs. 13–19 (Middle Jurassic, France); Cytheridae, Cytherinae.
Knoxiella reticulata Copeland, 1957; p. 933, pl. 114, figs. 1–10, text-fig. 1 (Middle Devonian, New York); Kloedenellidae, Knoxinae [*sic*].
Kobayashiina hyalinosa Hanai, 1957*c*; p. 30, pl. 4, fig. 5a–b, text-fig. 6a–b (Upper Pliocene, Japan); Cytheridae, Cytheropterinae.
Krithe rutoti Keij, 1957; p. 86, pl. 8, figs. 5–10 (Lower Eocene, Belgium); Cytheridae, Cytherideidinae.
Laccochilina (Laccochilina) bulbata Jaanusson, 1957; p. 248, pl. 2, figs. 9–14 (Lower to Middle Ordovician, Sweden); Eurychilinidae, Chilobolbininae.
Laccochilina (Laccochilina) paucigranosa Jaanusson, 1957; p. 244, pl. 1, figs. 12–17, text-fig. 11c (Middle Ordovician, Sweden); Eurychilinidae, Chilobolbininae.
Laccochilina (Prochilina) ostrogothica Jaanusson, 1957; p. 253, pl. 3, figs. 5–8 (Middle Ordovician, Sweden); Eurychilinidae, Chilobolbininae.
Leguminocythereis dumonti Keij, 1957; p. 123, pl. 13, fig. 8; pl. 16, figs. 5–6 (Upper Eocene, Belgium); incertae sedis.
Leguminocythereis genappensis Keij, 1957; p. 124, pl. 15, fig. 19; pl. 16, figs. 1–4 (Middle Eocene, Belgium); incertae sedis.
Leperditella altiforma Harris, 1957; p. 149, pl. 2, fig. 7a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Leperditella gibba Harris, 1957; p. 152, pl. 2, fig. 11a–c (Middle Ordovician, Oklahoma); Leperditellidae.
Leperditella incisa Harris, 1957; p. 153, pl. 3, fig. 4a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Leperditella? jonesinoides Harris, 1957; p. 153, pl. 3, fig. 6a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Leperditella obesa Harris, 1957; p. 154, pl. 3, fig. 5a–c (Middle Ordovician, Oklahoma); Leperditellidae.
Leperditella porosa Harris, 1957; p. 155, pl. 3, figs. 7–8 (Middle Ordovician, Oklahoma); Leperditellidae.
Leperditella? subcygnoides Harris, 1957; p. 157, pl. 3, fig. 9a–c (Middle Ordovician, Oklahoma); Leperditellidae.
Leperditella valida Harris, 1957; p. 151, pl. 2, fig. 10a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Leperditia pergracilis Ulrich and Swain, 1957; p. 547, pl. 59, fig. 16a–b (Middle Ordovician, Pennsylvania); Leperditiidae, Leperditiinae.
Leptocythere lacertosa ciliata Hartmann, 1957*b*, n. subsp.; p. 110, text-figs. 1–2, 4, 6 (Recent, North Sea coast, Germany).
Leptocythere lacertosa maior Hartmann, 1957*b*, n. subsp.; p. 110, figs. 3, 5, 7–8 (Recent, North Sea coast, Germany).
Levisulculus lineatus Jaanusson, 1957; p. 322, pl. 8, figs. 12–15, text-fig. 26c–d (Middle Ordovician, Sweden); Piretellidae, Tvaerenellinae.
Liocypris crassa Grékoff, 1957; p. 39, pl. 1, figs. 7–9, text-fig. 6 (Lower Cretaceous, Belgium); Cyprididae, Cypridinae.
Lomatobolbina craspedota Jaanusson, 1957; p. 399, pl. 12, figs. 9–12 (Middle Ordovician, Sweden); Sigmoopsidae.
Lophocythere multicostata Oertli, 1957*a*; p. 667, pl. 4, figs. 146–153 (Upper Jurassic, France); Cytheridae, Progonocytherinae.
Loxoconcha curryi Keij, 1957; p. 139, pl. 21, fig. 15 (Upper Eocene, England); Cytheridae, Loxoconchinae.
Loxoconcha kendrickensis Puri, 1957*c*; p. 192, pl. 3, figs. 11–14 (Upper Eocene, Florida); Cytheridae, Loxoconchinae.
Loxoconcha kuiperi Keij, 1957; p. 141, pl. 21, fig. 9; pl. 22, fig. 8 (Oligocene, Belgium); Cytheridae, Loxoconchinae.
Loxoconcha marionensis Puri, 1957*c*; p. 191, pl. 3, figs. 7–10 (Upper Eocene, Florida); Cytheridae, Loxoconchinae.
Loxoconcha neusensis Brown, 1957; p. 23, pl. 6, fig. 10 (Upper Cretaceous, North Carolina); Cytheridae.
Loxoconcha seraphae Brown, 1957; p. 23, pl. 6, figs. 9–11 (Upper Cretaceous, North Carolina); Cytheridae.

Macrodentina maculata Malz, 1957; p. 250 (figured in Martin and Weiler, 1957; pl. 1, fig. 2) (Upper Jurassic, Germany).
Macrodentina punctata Oertli, 1957*a*; p. 669, pl. 5, figs. 156–173; pl. 6, figs. 174–178 (Upper Jurassic, France); Cytheridae.
Macronotella elegans Harris, 1957; p. 184, pl. 4, fig. 12a–c (Middle Ordovician, Oklahoma); Leperditellidae.
Macronotella mcgeheei Harris, 1957; p. 185, pl. 9, fig. 14a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Macronotella upsoni Harris, 1957; p. 186, pl. 9, fig. 15a–b (Middle Ordovician, Oklahoma); Leperditellidae.
Metacypris bitufoensis Grékoff, 1957; p. 72, pl. 5, figs. 77–79, text-fig. 30 (Upper Jurassic, Belgian Congo); Cytheridae, Xestoleberidinae.
Metacypris cornuta Grékoff, 1957; p. 79, pl. 6, figs. 93–95, text-fig. 35 (Upper Jurassic, Belgian Congo); Cytheridae, Xestoleberidinae.
Metacypris cuneiformis lualabaensis Grékoff, 1957, new subsp.; p. 68, pl. 4, figs. 64–67, text-fig. 27 (Upper Jurassic, Belgian Congo); Cytheridae, Xestoleberidinae.
Metacypris mushopensis Grékoff, 1957; p. 75, pl. 6, figs. 107–108, text-fig. 32 (Upper Jurassic, Belgian Congo); Cytheridae, Xestoleberidinae.
Metacypris passaui longaensis Grékoff, 1957, new subsp.; p. 71, pl. 4, figs. 72–74, text-fig. 29 (Upper Jurassic, Belgian Congo); Cytheridae, Xestoleberidinae.
Metacypris polita Grékoff, 1957; p. 83, pl. 6, figs. 100–101, text-fig. 38 (Lower Cretaceous, Belgium); Cytheridae, Xestoleberidinae.
Metacypris postangularis kanianiaensis Grékoff, 1957, new subsp.; p. 76, pl. 5, figs. 85–87, text-fig. 33 (Upper Jurassic, Belgian Congo); Cytheridae, Xestoleberidinae.
Metacypris pustulosa Grékoff, 1957; p. 80, pl. 4, figs. 75–76, text-fig. 36 (Lower Cretaceous, Belgian Congo); Cytheridae, Xestoleberidinae.
Metacypris tenuimarginata Oertli, 1957*b*; p. 765, pl. 23, figs. 15–24 (Middle Jurassic, France); Cytheridae, Xestoleberidinae.
Metacypris trinodosa litokoensis Grékoff, 1957, new subsp.; p. 77, pl. 5, figs. 88–92, text-fig. 34 (Upper Jurassic, Belgian Congo); Cytheridae, Xestoleberidinae.
Metacytheropteron elegans Oertli, 1957*a*; p. 664, pl. 4, figs. 116–124 (Upper Jurassic, France); Cytheridae, Cytherinae.
Microcythere schüttei Hartmann, 1957*b*; p. 108, text-figs. 9–16 (Recent, North Sea coast, Germany).
Monoceratella brevispinata Harris, 1957; p. 244, pl. 8, fig. 10a–b (Middle Ordovician, Oklahoma); Acronotellidae.
Monoceratina prothroensis Butler and Jones, 1957; p. 22, pl. 4, fig. 1a–d (Upper Cretaceous, Louisiana); Cytheridae, Bythocytherinae.
Monoceratina sagitta Butler and Jones, 1957; p. 25, pl. 4, fig. 6a–c (Upper Cretaceous, Louisiana); Cytheridae, Bythocytherinae.
Morinina maringaensis Grékoff, 1957; p. 56, pl. 3, figs. 41–43, text-fig. 18 (Lower Cretaceous, Belgian Congo); Cyprididae, Cyprideinae.
Munseyella clavata Triebel, 1957; p. 298, pl. 4, fig. 30; pl. 5, figs. 31–39 (Pleistocene, California); Cytheridae, Cytherinae.
Munseyella morrisi Triebel, 1957; p. 295, pl. 1, fig. 6; pl. 2, figs. 7–14; pl. 3, fig. 15 (Pleistocene, California); Cytheridae, Cytherinae.
Munseyella muehlemanni van den Bold, 1957*b*; p. 238, pl. 3, fig. 4a–c (Middle Miocene, Trinidad); Cytheridae, Cytherinae.
Munseyella pedroensis Triebel, 1957; p. 297, pl. 3, figs. 16–22 (Pleistocene, California); Cytheridae, Cytherinae.
Munseyella similis Triebel, 1957; p. 297, pl. 4, figs. 23–29 (Pleistocene, California); Cytheridae, Cytherinae.
Murrayina barclayi McLean, 1957; p. 87, pl. 11, fig. 4a–f (Miocene, Virginia); Cytheridae, Trachyleberinae.
Naviculina longa Liubimova, 1957 (in Mandelstam and others, 1957); p. 179, pl. 3, figs. 5–6 (Middle Jurassic, Ukraine, Russia); Cytheridae.
Nereina barenzovensis Mandelstam, 1957; p. 180, pl. 3, figs. 7–8 (Recent, Barents Sea); Cytheridae.
Oecematobolbina nitens Jaanusson, 1957; p. 403, pl. 12, figs. 13–19 (Middle Ordovician, Sweden); Sigmoopsidae.
Orthonotacythere caput-mortuum Martin, 1957*a*; p. 220, pl. 2, figs. 6–7 (Upper Jurassic, Germany); Cytheridae.
Orthonotacythere sulcata Brown, 1957; p. 23, pl. 6, figs. 6–8 (Upper Cretaceous, North Carolina); Cytheridae.
Orthonotacythere tarensis Brown, 1957; p. 24, pl. 6, figs. 1–2 (Upper Cretaceous, North Carolina); Cytheridae.
Paegnium tanaum Kesling, 1957*b*; p. 23, pl. 1, figs. 1–12 (Middle Devonian, New York).
Paenula superba Kuznetsova, 1957; p. 176, pl. 2, fig. 6 (Lower Cretaceous, Caucasus, Russia); Cytheridae.
Paijenborchella longicosta Keij, 1957; p. 156, pl. 21, figs. 1–4 (Middle Eocene, Belgium); Cytheridae, Cytherurinae.
Paijenborchellina apscheronensis Kuznetsova, 1957; p. 181, pl. 2, fig. 8 (Lower Cretaceous, Caucasus, Russia); Cytheridae.
Paijenborchellina excelens Kuznetsova, 1957; p. 181, pl. 4, figs. 4–5 (Lower Cretaceous, Caucasus, Russia); Cytheridae.
Palmenella californica Triebel, 1957; p. 292, pl. 1, figs. 1–5 (Pleistocene, California); Cytheridae, Cytherinae.
Paracypria longaensis Grékoff, 1957; p. 42, pl. 1, figs. 15–16, text-fig. 7 (Upper Jurassic, Belgian Congo); Cyprididae, Candoninae.
Paracypria longaensis longaensis Grékoff, 1957, new subsp.; p. 42, pl. 1, figs. 15–16, text-fig. 7 (Upper Jurassic, Belgian Congo); Cyprididae, Candoninae.
Paracypria longaensis liloensis Grékoff, 1957, new subsp.; p. 43, pl. 1, fig. 17, text-fig. 8 (Upper Jurassic, Belgian Congo); Cyprididae, Candoninae.
Paracypridea obovata congoensis Grékoff, 1957, new subsp.; p. 57, pl. 3, figs. 44–46, text-fig. 19 (Lower Cretaceous, Belgian Congo); Cyprididae, Cyprideinae.
Paracyprinotus similis Schneider, 1957; p. 172, pl. 1, fig. 5 (Pliocene, Russia); Cyprididae.
Paracytheretta? maracensis van den Bold, 1957*a*; p. 11, pl. 3, fig. 11a–b (Paleocene, Trinidad); Cytheridae, Cytherettinae.
Paracytheridea (Paracytheridea) brusselensis Keij, 1957; p. 158, pl. 19, fig. 5; pl. 22, fig. 5 (Middle Eocene, Belgium); Cytheridae, Cytherurinae.
Paracytheridea (Paracytheridea) grignonensis Keij, 1957; p. 161, pl. 19, fig. 11; pl. 22, fig. 1 (Middle Eocene, France); Cytheridae, Cytherurinae.
Paracytheroma costata Hartmann, 1957*a*; p. 158, pl. 49, figs. 124–125; pl. 50, figs. 126–130 (Recent, El Salvador); Cytheridae, Cytherominae.
Paracytheroma levis Hartmann, 1957*a*; p. 155, pl. 47, figs. 105–106; pl. 48, figs. 107–114; pl. 49, figs. 112, 115 (Recent, El Salvador); Cytheridae, Cytherominae.
Paracytheroma unduli-marginata Hartmann, 1957*a*; p. 156, pl. 49, figs. 16–20; pl. 50, figs. 21–23 (Recent, El Salvador); Cytheridae, Cytherominae.
Paraeucypris tota Schneider, 1957; p. 172, pl. 1, fig. 7 (Pliocene, Russia?); Cyprididae.
Paraparchites? circulantis Harris, 1957; p. 142, pl. 6, fig. 1a–c (Middle Ordovician, Oklahoma); Leperditellidae.
Paraschmidtella multicavata Harris, 1957; p. 171, pl. 4, fig. 13a–c (Middle Ordovician, Oklahoma); Leperditellidae.
Paraschmidtella oviforma Harris, 1957; p. 172, pl. 4, fig. 14a–b (Middle Ordovician, Oklahoma); Leperditellidae.

Tanella miurensis Hanai, 1957*a*; p. 462, pl. 9, fig. 1a–e, text-fig. 2i–j (Recent, Japan); Cytheridae, Leptocytherinae.
Taxodiella fiscellaformis Kuznetsova, 1957; p. 174, pl. 2, fig. 4 (Lower Cretaceous, Caucasus, Russia); Cytheridae.
Tetradellina henningsmoeni Harris, 1957; p. 251, pl. 8, fig. 14a–b (Middle Ordovician, Oklahoma); Tetradellidae.
Thalassocypria aestuarina Hartmann, 1957*a*; p. 135, pl. 39, figs. 1–11; pl. 40, figs. 12–16 (Recent, El Salvador); Cyprididae.
Thalassocypria elongata Hartmann, 1957*a*; p. 137, pl. 40, figs. 17–23; pl. 41, figs. 24–27 (Recent, El Salvador); Cyprididae.
Thomasatia auricula Harris, 1957; p. 246, pl. 8, fig. 11a–b (Middle Ordovician, Oklahoma); Tetradellidae.
Thomasatia bromidensis Harris, 1957; p. 247, pl. 8, figs. 12a–b, 16 (Middle Ordovician, Oklahoma); Tetradellidae.
Thomasatia simplex Harris, 1957; p. 248, pl. 8, figs. 15, 17a–b (Middle Ordovician, Oklahoma); Tetradellidae.
"*Toulminia*" *hokkaidoana* Hanai, 1957*b*; p. 479, pl. 11, fig. 2a–b, text-fig. 5a–b (Upper Pliocene, Japan); Cytheridae, Pectocytherinae. [Generic name now *Munseyella.*]
"*Toulminia*" *japonica* Hanai, 1957*b*; p. 478, pl. 11, fig. 1a–e, text-figs. 3a–b, 4a–b (Recent, Japan); Cytheridae, Pectocytherinae. [Generic name now *Munseyella.*]
Trachyleberis citrusensis Puri, 1957*c*; p. 196, pl. 10, figs. 1–12 (Upper Eocene, Florida); Cytheridae, Trachyleberinae.
Trachyleberis(?) praecursora Brown, 1957; p. 15, pl. 7, figs. 20–25 (Upper Cretaceous, North Carolina); Cytheridae.
Triginglymus heistensis Keij, 1957; p. 127, pl. 18, figs. 7–8; pl. 19, figs. 3–4 (Upper Eocene, Belgium); incertae sedis.
Trochinius semiconcentricus Kuznetsova, 1957; p. 176, pl. 2, fig. 5 (Lower Cretaceous, Caucasus, Russia); Cytheridae.
Trubinella teisi Harris, 1957; p. 222, pl. 9, fig. 12a–b (Middle Ordovician, Oklahoma); Hollinidae.
Uhakiella aequigranosa Jaanusson, 1957; p. 290, pl. 5, figs. 10–11 (Middle Ordovician, Sweden); Piretellidae, Piretellinae.
Uhakiella periacantha Jaanusson, 1957; p. 292, pl. 5, figs. 12–17, text-figs. 6, 24–25 (Middle Ordovician, Sweden); Piretellidae, Piretellinae.
Velarocythere cacumenata Brown, 1957; p. 21, pl. 5, figs. 13–15 (Upper Cretaceous, North Carolina); Cytheridae.
Velarocythere eikonata Brown, 1957; p. 22, pl. 5, figs. 10–12 (Upper Cretaceous, North Carolina); Cytheridae.
Velarocythere legrandi Brown, 1957; p. 21, pl. 5, figs. 1–4 (Upper Cretaceous, North Carolina); Cytheridae.
Velarocythere scuffeltonensis Brown, 1957; p. 21, pl. 5, figs. 5–9 (Upper Cretaceous, North Carolina); Cytheridae.
Vernoniella sequana Oertli, 1957*a*; p. 659, pl. 3, figs. 70–85 (Upper Jurassic, France); Cytheridae, Cytherideinae.
Vicinia sutilis Kuznetsova, 1957; p. 183, pl. 4, fig. 1 (Lower Cretaceous, Caucasus, Russia); Cytheridae.
Winchellatia cornuta Harris, 1957; p. 220, pl. 9, fig. 4a–b (Middle Ordovician, Oklahoma); Hollinidae.
Xestoleberis mauryae van den Bold, 1957*a*; p. 12, pl. 1, fig. 6a–b (Paleocene, Trinidad); Cytheridae, Xestoleberinae.
Xestoleberis zuberensis Puri, 1957*c*; p. 194, pl. 6, figs. 13–16 (Upper Eocene, Florida); Cytheridae, Xestoleberinae.

NEW NAMES IN 1957

Amphissites carinodus Cooper, 1957; new name for *A. carinatus* Cooper, 1946 (non Cooper, 1941); p. 674.
Bairdia angustata Cooper, 1957; new name for *B. angusta* Cooper, 1946 (non *B. angusta* (Münster) Jones, 1849); p. 674.
Bairdia aculeala Cooper, 1957; new name for *B. aculeata* Cooper, 1941 (non Bonnema, 1940); p. 674.
Bairdia bradyi van den Bold, 1957*b*; new name for *Bairdia foveolata* Brady, 1868, p. 56 (non Bosquet, 1852, p. 21 = *Monsmirabilia foveolata* (Bosquet)); p. 236, pl. 1, fig. 5.
Cypridina homoedwardsiana Keij, 1951; new name for *Cypridina edwardsiana* (Bosquet, 1852) (non de Koninck, 1841); p. 43, pl. 7, figs. 16–18; pl. 18, figs. 15–16; Cypridinidae.
Henryhowella Puri, 1957*d*; new name for *Howella* Puri, 1956 (non Ogilby, 1899).
Munseyella van den Bold, 1957*a*; new name for *Toulminia* Munsey, 1953 (non Zittel, 1878).
NEOCYTHERIDEIDINAE Puri, 1957*a*; p. 305; new name for subfamily Cytherideidinae Puri, 1952, because the type genus *Cytherideis* = *Cypridea*; new subfamily of Cytheridae to include the genera: *Neocytherideis* Puri, 1952; *Sahnia* Puri, 1952; *Krithe* Brady, Crosskey and Robertson, 1874; *Copytus* Skogsberg, 1939; *Hemicytherideis* Ruggieri, 1952; *Cushmanidea* Blake, 1933; *Pontocythere* Dubovsky, 1939; "*Cytherideis*" of authors.
Trochinius Mandelstam, 1957; new name for *Trochiscus* Mandelstam, 1956 (non Heyden, 1826) [*Cythere punctatula* Jones, 1849, p. 11, pl. 1, fig. 2]; p. 175.

FORMS WITH NOMENCLATURA APERTA IN 1957

Actinochilina sp. *A*, Jaanusson, 1957; p. 258, pl. 3, figs. 11–12, text-fig. 17 (Middle Ordovician, Sweden); Eurychilinidae, Chilobolbininae.
Alatacythere? sp., Butler and Jones, 1957; p. 32, pl. 2, fig. 3a–c (Upper Cretaceous, Louisiana); Cytheridae, Brachycytherinae.
Apatobolbina sp., Kesling and Rogers, 1957; p. 999, pl. 129, figs. 8–11 (Middle Silurian, geographic location not given); Beyrichiidae.
Argilloecia sp., Butler and Jones, 1957; p. 11, pl. 6, fig. 2 (Upper Cretaceous, Louisiana); Cyprididae, Pontocypridinae.
Bairdia sp., van den Bold, 1957*a*; p. 6, pl. 2, fig. 7 (Paleocene, Trinidad); Bairdiidae.
Bairdia sp., van den Bold, 1957*a*; p. 6, pl. 2, fig. 8 (Paleocene, Trinidad); Bairdiidae.
Bairdoppilata sp., Keij, 1957; p. 54, pl. 1, fig. 22 (Middle Eocene, France); Bairdiidae.
Bolbina sp. *A*, Jaanusson, 1957; p. 332, pl. 5, figs. 18–19 (Middle Ordovician, Sweden).
Bolbina sp. *B*, Jaanusson, 1957; p. 333, pl. 5, fig. 20 (Middle Ordovician, Sweden).
Brachycythere? kugleri var., van den Bold, 1957*a*; p. 11, pl. 4, fig. 9 (Paleocene, Trinidad); Cytheridae, Brachycytherinae.
Bradleya sp., van den Bold, 1957*b*; p. 241, pl. 2, fig. 3a–b (Oligo-Miocene, Trinidad); Cytheridae, Cytherinae.
Bythocypris sp., Butler and Jones, 1957; p. 13, pl. 1, fig. 1 (Upper Cretaceous, Louisiana); Bairdiidae, Bairdiinae.
Bythocypris? sp., van den Bold, 1957*a*; p. 7, pl. 2, fig. 10a–b (Paleocene, Trinidad); Bairdiidae.
Bythocypris sp. cf. *B. granti* Ulrich, Harris, 1957; p. 259, pl. 10, fig. 13a–b (Middle Ordovician, Oklahoma); Bairdiidae.
Bythocypris sp. *A*, Oertli, 1957*a*; p. 653, pl. 1, figs. 30–31 (Upper Jurassic, France); Bairdiidae.
Candonopsis sp., Grékoff, 1957; p. 44, pl. 1, figs. 18–19 (Purbeck-Wealden, Belgian Congo); Cyprididae, Candoninae.
"*Chilobolbina*" sp., Kesling and Rogers, 1957; p. 1000, pl. 127, figs. 10–14 (Middle Silurian, geographic location not given); Beyrichiidae.
Cypridea sp., Grékoff, 1957; p. 55, pl. 2, fig. 37 (Lower Cretaceous, Belgian Congo); Cyprididae, Cyprideinae.
CYPRIDIDAE gen. et sp. indet., Grékoff, 1957; p. 60, pl. 3, figs. 51–52 (Lower Cretaceous, Wealden); Cyprididae.

Cytherella sp., van den Bold, 1957*b*; p. 235, pl. 1, fig. 3 (Oligocene? to Pliocene, Trinidad); Cytherellidae.
Cytherella sp., Butler and Jones, 1957; p. 9, pl. 6, fig. 5 (Upper Cretaceous, Louisiana); Cytherellidae.
Cytherella sp., Brown, 1957; p. 8, pl. 1, figs. 1–2 (Upper Cretaceous, North Carolina); Cytherellidae.
Cytherella sp., van den Bold, 1957*a*; p. 4, pl. 2, fig. 1 (Paleocene, Trinidad); Cytherellidae.
Cytherella sp., Puri, 1957*c*; p. 207, pl. 2, figs. 17–20 (Upper Eocene, Florida); Cytherellidae.
Cytherella sp. *B*, Puri, 1957*c*; p. 207, pl. 3, figs. 1–2 (Upper Eocene, Florida); Cytherellidae.
Cytherelloidea sp. *A*, Oertli, 1957*a*; p. 652, pl. 1, figs. 16–18 (Upper Jurassic, France); Cytherellidae.
Cytherelloidea sp., Butler and Jones, 1957; p. 10, pl. 1, fig. 5; pl. 6, fig. 5 (Upper Cretaceous, Louisiana); Cytherellidae.
Cytherelloidea sp., van den Bold, 1957*a*; p. 5, pl. 4, fig. 1 (Paleocene, Trinidad); Cytherellidae.
CYTHERIDEINAE gen.? sp. 1, Oertli, 1957*a*; p. 661, pl. 3, figs. 86–91 (Upper Jurassic, France); Cytheridae, Cytherideinae.
Cytheromorpha sp., van den Bold, 1957*a*; p. 7, pl. 4, fig. 2 (Paleocene, Trinidad); Cytheridae, Cytherinae.
Cytheropteron sp., Keij, 1957; p. 151, pl. 21, fig. 14 (Middle to Upper Eocene, Belgium); Cytheridae, Cytherurinae.
Cytherura sp., van den Bold, 1957*b*; p. 245, pl. 4, fig. 11 (Oligo-Miocene, Trinidad); Cytheridae, Cytherurinae.
Cytherura? sp. *A*, Oertli, 1957*a*; p. 666, pl. 4, figs. 137–139 (Upper Jurassic, France); Cytheridae, Cytherurinae.
Cytherura sp. *B*, Oertli, 1957*a*; p. 667, pl. 4, figs. 140–145 (Upper Jurassic, France); Cytheridae, Cytherurinae.
Eocytheropteron sp., Oertli, 1957*b*; p. 762, pl. 22, figs. 22–23 (Middle Jurassic, France); Cytheridae, Cytherurinae.
Erpetocypris? sp., Oertli, 1957*b*; p. 756, pl. 21, figs. 1–4 (Middle Jurassic, France); Cyprididae, Erpetocypridinae.
Eucythere sp., McLean, 1957; p. 76, pl. 8, fig. 3a–b (Miocene, Virginia); Cytheridae, Eucytherinae.
Eucythere sp., van den Bold, 1957*a*; p. 7, pl. 1, fig. 4 (Paleocene, Trinidad); Cytheridae, Cytherideinae.
Gomphocythere sp. 1, Oertli, 1957*b*; p. 763, pl. 22, figs. 24–31 (Middle Jurassic, France); Cytheridae, Xestoleberinae.
Gomphocythere? sp. 2, Oertli, 1957*b*; p. 764, pl. 23, figs. 1–4 (Middle Jurassic, France); Cytheridae, Xestoleberinae.
Gomphocythere sp. 3, Oertli, 1957*b*; p. 764, pl. 23, figs. 5–14 (Middle Jurassic, France); Cytheridae, Xestoleberinae.
Haplocytheridea sp., Keij, 1957; p. 64, pl. 2, fig. 16 (Middle Eocene, France); Cytheridae, Cytherideinae.
Iliocythere sp. XV, Hartmann, 1957*a*; p. 146, pl. 44, fig. 61 (Recent, El Salvador); Cytheridae, Cytherinae.
Isochilina sp., Swain, 1957; p. 553, pl. 60, fig. 6 (Middle Ordovician, New York); Leperditiidae, Isochilininae.
Klieana? sp., Grékoff, 1957; p. 65, pl. 6, figs. 110–111, text-fig. 25 (Upper Jurassic, Belgian Congo); Cytheridae, Cytherinae.
Laccochilina (Laccochilina) sp. *A*, Jaanusson, 1957; p. 246, pl. 2, fig. 1 (Middle Ordovician, Sweden); Eurychilinidae, Chilobolbininae.
Laccochilina (Laccochilina) sp. *B*, Jaanusson, 1957; p. 247, pl. 2, figs. 2–4 (Middle Ordovician, Sweden); Eurychilinidae, Chilobolbininae.
Laccochilina (Laccochilina) sp. *C*, Jaanusson, 1957; p. 247, pl. 2, figs. 5–8 (Middle Ordovician, Sweden); Eurychilinidae, Chilobolbininae.
Macrocypris sp., Butler and Jones, 1957; p. 13, pl. 1, fig. 7a–b (Upper Cretaceous, Louisiana); Bairdiidae, Bairdiinae.
Macrodentina? sp., Grékoff, 1957; p. 66, pl. 6, fig. 103 (Upper Jurassic, Belgian Congo); Cytheridae, Progonocytherinae.
"*Macrodentina*" "*g*", Oertli, 1957*a*; p. 672, pl. 6, figs. 188–204 (Upper Jurassic, France); Cytheridae.
Macrodentina sp. *B*, Oertli, 1957*a*; p. 670, pl. 6, figs. 182–184 (Upper Jurassic, France); Cytheridae.
Macrodentina? sp., Oertli, 1957*b*; p. 761, pl. 22, figs. 20–21 (Middle Jurassic, France); Cytheridae, Progonocytherinae.
Metacypris sp. 390, Grékoff, 1957; p. 84, pl. 6, figs. 86, 97 (Purbeck-Wealden, Belgian Congo); Cytheridae, Xestoleberidinae.
Metacypris sp. 396, Grékoff, 1957; p. 84, pl. 6, fig. 102 (Purbeck-Wealden, Belgian Congo); Cytheridae, Xestoleberidinae.
Monoceratina sp., Butler and Jones, 1957; p. 25, pl. 4, fig. 5 (Upper Cretaceous, Louisiana); Cytheridae, Bythocytherinae.
Monoceratina sp., Keij, 1957; p. 165, pl. 14, fig. 12 (Middle Eocene, Belgium); Cytheridae, Bythocytherinae.
Monoceratina? sp. *A*, Oertli, 1957*a*; p. 666, pl. 4, figs. 131–136 (Upper Jurassic, France); Cytheridae, Bythocytherinae.
Oecematobolbina sp. *A*, Jaanusson, 1957; p. 405, pl. 12, figs. 20–21 (Middle Ordovician, Sweden); Sigmoopsidae.
Oepikium sp. *A*, Jaanusson, 1957; p. 408, pl. 14, figs. 4–5 (Middle Ordovician, Sweden); Oepikiumidae.
Paracypris? sp. *A*, Oertli, 1957*a*; p. 652, pl. 1, fig. 23 (Upper Jurassic, France); Cyprididae, Cypridinae.
Paracypris sp. *B*, Oertli, 1957*a*, p. 653, pl. 1, figs. 19–22 (Upper Jurassic, France); Cyprididae, Cypridinae.
Paracypris sp. *C*, Oertli, 1957*a*; p. 653, pl. 1, fig. 24 (Upper Jurassic, France); Cyprididae, Cypridinae.
Paracypris sp., Butler and Jones, 1957; p. 11, pl. 1, fig. 6a–b (Upper Cretaceous, Louisiana); Cyprididae, Cypridinae.
Paracypris sp., Keij, 1957; p. 52, text-fig. 7 (Upper Eocene, Belgium); Cyprididae, Cypridinae.
Paracypris? sp., Keij, 1957; p. 52, text-fig. 8 (Middle Eocene, Belgium); Cyprididae, Cypridinae.
Primitiella sp., Swain, 1957; p. 565, pl. 62, fig. 10a–c (Middle Ordovician, Pennsylvania); Leperditellidae.
PROGONOCYTHERINAE? gen. indet., sp. *A*, Oertli, 1957*a*; p. 676, pl. 7, figs. 229–233 (Upper Jurassic, France); Cytheridae.
Propontocypris sp., van den Bold, 1957*a*; p. 5, pl. 1, fig. 3a–b (Paleocene, Trinidad); Cyprididae, Pontocypridinae.
Pseudocythere sp., Keij, 1957; p. 164, pl. 2, fig. 2 (Upper Eocene, Belgium); Cytheridae, Bythocytherinae.
Pterygocythereis sp., van den Bold, 1957*a*; p. 9, pl. 4, fig. 6a–b (Paleocene, Trinidad); Trachyleberinae.
Puriana? sp., van den Bold, 1957*a*; p. 9, pl. 3, fig. 9a–b (Paleocene, Trinidad); Trachyleberinae.
Ruggieria sp., Keij, 1957; p. 113, pl. 14, fig. 10; pl. 15, fig. 7 (Pliocene, France); Cytheridae, Trachyleberidinae.
Scabriculocypris? sp., Grékoff, 1957; p. 59, pl. 3, fig. 50, text-fig. 21 (Purbeck-Wealden, Belgian Congo); Cyprididae, Cyprideinae.
Schizocythere sp., Keij, 1957; p. 155, pl. 20, fig. 13 (Pliocene, France); Cytheridae, Cytherurinae.
Sigmoopsis sp. *A*, Jaanusson, 1957; p. 383, pl. 11, fig. 9 (Middle Ordovician, Sweden); Sigmoopsidae.
Sigmoopsis sp. *B*, Jaanusson, 1957; p. 384, pl. 11, fig. 10 (Middle Ordovician, Sweden); Sigmoopsidae.
Theriosynoecum? sp. 446, Grékoff, 1957; p. 85, pl. 6, fig. 104 (Upper Jurassic, Belgian Congo); Cytheridae, Xestoleberidinae.
Trachyleberis? sp., van den Bold, 1957*a*; p. 9, pl. 3, fig. 5a–b (Paleocene, Trinidad); Trachyleberinae.

SUPPLEMENT TO BIBLIOGRAPHY FOR 1950–1956

ADAMCZAK, F.
1956 – *Polyzygia Gürich, an ostracod genus from the Givetian of the Holy Cross Mountains.* Acta Pal. Polonica, vol. 1, no. 1, pp. 35–48, pls. 1–2, text-fig. 1.

BARTENSTEIN, H.
1956 – *Zur Mikrofauna des englischen Hauterive.* Senckenbergiana Lethaea, vol. 37, no. 5/6, pp. 509–533, pls. 1–3.

BOLIN, E. J.
*1956 – *Upper Cretaceous foraminifera, Ostracoda, and Radiolaria from Minnesota.* Jour. Pal., vol. 30, no. 2, pp. 278–298, pls. 37–39, 5 text-figs.

CHOCZEWSKI, J.
1955 – *Ostracoda of lower Sarmat at Dwikozy near Sandomierz.* Polsk. Tow. Geol., Rocznik, vol. 25, no. 1, pp. 55–87, pls. 2–3, 5 text-figs.

EGOROVA, L. N.
1956 – *[Ostracoda of the Morsovo formation in the Russian Platform.]* In: GRIAZNOV, N. K., *[Contributions to the geology of the regions of the Russian Platform and the northern Caucasus and to the technical problems of petroleum geology.]* U.S.S.R., Minist. Petrol. Industry, All-Union Oil and Gas Sci.-Res. Inst. (VNII), Trudy (Trans.), fasc. 9, pp. 103–115, pls. 1–2.

GOERLICH, F.
1956 – *Mikropaläontologische und stratigraphische Untersuchungen im Königreich Yemen.* Pal. Zeitschr., vol. 30, no. 3/4, pp. 213–214.

GRÉKOFF, N., AND DEROO, G.
1956 – *Algunos ostrácodos del Cretácico medio del norte de España.* Spain, Inst. Invest. Geol. "Lucas Mallada," Estud. Geol., vol. 12, no. 31–32, pp. 215–226 (Spanish), 227–235 (French), pls. 46–47.

HIBBARD, R. R.
1951 – *Collecting and studying local microfossils.* Hobbies (Buffalo Museum of Science), vol. 31, no. 3, pp. 46–51.

HOU, Y. T.
1956 – *The Ordovician ostracods from western Chekiang.* Acta Pal. Sinica, vol. 4, no. 4, pp. 535–558 (Chinese), 558–597 (English), pls. 1–4.

KALJO, D., ORASPOLD, A., ROOMUSOKS, A., SARV, L., AND STUMBUR, H.
*1956 – *[List of the fauna of the Ordovician of the Estonian S.S.R.; II – Middle Ordovician.]* [Estonian with Russian summary.] Eesti N.S.V. Tead. Akad. Juures, Lood. Selts, Abiks Lood. [Acad. Sci. Estonian S.S.R., Soc. Nat., Guidebook for Observers of Nature], no. 25, pp. 1–62 (ostracodes, pp. 45–53).

KLINGLER, W.
1955*a* *Mikrofaunistische und stratigraphisch-fazielle Untersuchungen im Kimmeridge und Portland des Weser-Aller-Gebietes.* Geol. Jahrb., vol. 70, pp. 167–246, pls. 6–21, 7 text-figs. (previously not seen).

*1955*b* *Mikrofaunistische und stratigraphisch-fazielle Untersuchungen im Kimmeridge und Portland des Weser-Aller-Gebietes.* Geol. Jahrb., vol. 70, pp. 575–576.

*1956 – *Zur Gliederung des Oberen Malm in Nordwestdeutschland.* Erdöl und Kohle, vol. 9 (1955), pp. 578–579.

LASERON, C. F.
*1956 – *The smallest shells in the world.* Australian Geogr. Mag., vol. 22, no. 8, pp. 16–17.

LUDBROOK, N. H.
1956 – *Microfossils from Pleistocene to Recent deposits, Lake Eyre, South Australia.* Roy. Soc. South Australia, Trans., vol. 79, pp. 37–45 (ostracodes, pp. 38, 42, 43, 45); pl. 1, figs. 5–8; 1 table.

MALZ, H.
*1956 – *Zur ontogenetischen Entwicklung des Schlosses bei Macrodentina-Arten (Ostrac.).* Senckenbergiana Lethaea, vol. 37, no. 5/6, pp. 535–541, pls. 1–2, 1 text-fig.

MARLIÈRE, R.
*1955 – *Sur l'âge de quelques phyllopodes et ostracodes mésozoïques du Congo Belge.* Soc. Belge Géol., Pal. Hydrol., Bull., vol. 64, no. 1, pp. 12–21.

1956 – *Sur quelques entomostracés de la cuvette congolaise.* Soc. Belge Géol., Pal. Hydrol., Bull., vol. 65, no. 1, pp. 45–52, 3 text-figs.

NETSKAIA, A. I., AND IVANOVA, V. A.
1956 – *First occurrence of ostracodes in the Lower Cambrian of eastern Siberia.* Akad. Nauk S.S.S.R., Doklady (C. R.), vol. 111, no. 5, pp. 1095–1097, text-fig. 1a–d.

POLENOVA, E. N.
1955 – *[Ostracoda of the Devonian of the Volga-Ural region.]* In: BYKOVA, E. V., AND POLENOVA, E. N., [*Foraminifera, Radiolaria and Ostracoda of the Devonian of the Volga-Ural region.*] All-Union Petrol. Sci. Res. Geol. Prosp. Inst. (VNIGRI), Trudy, new ser., no. 87, pp. 191–317, pls. 1–15.

PUCCI, A.
1955 – *Ostracodi pleistocenici della valle del Tronto.* Giorn. Geol. ser. 2, vol. 25, pp. 163–172, pl. 1, text-figs. 1–3.

RIOJA, E.
1951 – *Estudios carcinológicos; XXV – El hallazgo del genero Sphaeromicola en America (ostracodos, citeridos) y descripción de una nueva especie.* Inst. Biol., Anales, vol. 22, no. 1, pp. 168–179, pls. 1–2.

RUGGIERI, G.
1953 – *Correzzioni ad alcuni lavori su ostracodi dell'autore stesso.* Giorn. Geol. ser. 2, vol. 23, pp. 1–2.

RUSCONI, C.
1954 – *Fosiles cambricos y ordovicicos de San Isidro.* Bol. Pal. Buenos Aires, no. 30, pp. 1–4.

RUTTE, E.
*1956 – *Die Geologie des Schienerberges (Bodensee) und der Öhninger Fundstätten.* Neues Jahrb. Geol. Pal., Abh., vol. 102, pp. 143–282 (ostracodes, p. 165).

SARV, L. I.
1956 – *New ostracode types from the Vasalemma horizon (Upper Ordovician, Estonian Soviet Socialist Republic).* Akad. Nauk Estonian S.S.R., Inst. Geol., Trudy, vol. 1, pp. 30–40, pls. 1–2.

SMOUT, A. H., AND HAQUE, A. F. M. M.
*1956 – *A note on the larger foraminifera and Ostracoda of the Ranikot from the Nammal Gorge, Salt Range, Pakistan.* Pakistan, Geol. Survey, Rec., vol. 8, pt. 2, pp. 49–60 (ostracodes, pl. 10).

SOHN, I. G.
*1956 – *Pliocene ostracodes from Jackson Hole, Wyoming.* Wyoming Geol. Assoc., 11th Ann. Field Conf., Guidebook, pp. 120–122, text-figs. 1–34.

SWAIN, F. M.
1956 – *Early Tertiary ostracode zones of Uinta Basin.* In: *Geology and economic deposits of east-central Utah.* Intermountain Assoc. Petrol. Geol., 7th Ann. Field Conf., pp. 125–139, pls. 1–3.

SYLVESTER-BRADLEY, P. C.
*1951 – *Type species of the ostracod Rhombina.* Geol. Mag., vol. 88, no. 5, p. 371.

ZANINA, I. E.
1956 – *[Ostracoda of the Visean stage in the Moscow Basin.]* In: *[Microfauna of the U.S.S.R.; Symposium [Sbornik] VIII – Foraminifera, Bryozoa and Ostracoda of the Russian Platform, the Don Basin, the Tengiz Trough, and the Kuznetsk Basin.]* All-Union Petrol. Sci.-Res. Geol.-Prosp. Inst. (VNIGRI), Trudy (Trans.), new ser., no. 98, pp. 185–293, pls. 1–8.

SUPPLEMENT TO NEW SUBGENERA, GENERA, AND SUPRAGENERIC CATEGORIES IN 1950–1956

Altha Netskaia, 1955, in Polenova, 1955 [*A. modesta* Netskaia, in litt.]; p. 218 (Devonian, Russia); Devonian, marine; Kloedenellidae.

Aparchitellina Polenova, 1955 [*A. decorata* Polenova, 1955]; p. 193, pl. 2, figs. 1–9 (Devonian, Russia); Devonian, marine; Leperditellidae.

Cambria Netskaia and Ivanova, 1956 [*Cambria sibirica* Netskaia and Ivanova, 1956]; pp. 1095–1096, text-fig. 1a–d (Lower Cambrian, Siberia); Lower Cambrian, marine; Leperditiidae.

Leperditellina Netskaia, 1955, in Polenova, 1955 [*L. diffusa* Netskaia, in litt.]; pp. 197–198 (Devonian, Russia); Devonian, marine; Primitiopsidae.

Pseudonodellina Polenova, 1955 [*Nodella(?) parvula* Polenova, 1953 (reference to original description of this species uncertain)]; p. 205 (Devonian, Russia); Devonian, marine; Drepanellidae.

SUPPLEMENT TO NEW SPECIES, SUBSPECIES, AND VARIETIES IN 1950–1956

Acratia longa Zaspelova, 1955, in Polenova, 1955; p. 238, pl. 10, fig. 2a–b (Devonian, Russia); Bairdiidae.

Acratia praegnans Zanina, 1956; p. 250, pl. 7, fig. 9a–b (Lower Carboniferous, Visean, Russia); Bairdiidae.

Acratina rhomboidalis Polenova, 1955; p. 240, pl. 10, fig. 6a–b (Devonian, Russia); Bairdiidae.

Acratia rostrata Zanina, 1956; p. 251, pl. 8, fig. 4a–b (Lower Carboniferous, Visean, Russia); Bairdiidae.

Acratia vastigata Zaspelova, 1955, in Polenova, 1955; p. 239, pl. 10, fig. 1a–b (Devonian, Russia); Bairdiidae.

Alatacythere allinensis Grékoff and Deroo, 1956; pp. 221, 229, pl. 47, figs. 34–35 (Upper Cretaceous, transition from Cenomanian to Turonian, northern Spain); Cytherinae.

Altha reversa Polenova, 1955; p. 219, pl. 8, figs. 2–3 (Devonian, Russia); Kloedenellidae.

Amphissites amylosus Zanina, 1956; p. 233, pl. 5, figs. 8, 12 (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Amphissites formosus Zanina, 1956; p. 230, pl. 5, fig. 11 (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Amphissites gibbosus Zanina, 1956; p. 234, pl. 6, figs. 8, 9a–b (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Amphissites ramicosus Zanina, 1956; p. 233, pl. 5, fig. 5 (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Amphissites transversarius Polenova, 1955; p. 221, pl. 10, fig. 10 (Devonian, Russia); Kirkbyidae.

Amphissites verrucosus Zanina, 1956; p. 235, pl. 5, fig. 13 (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Aparchitellina adrianovae Polenova, 1955; p. 196, pl. 3, figs. 3–4 (Devonian, Russia); Leperditellidae.

Aparchitellina decorata Polenova, 1955; p. 194, pl. 2, figs. 1–9 (Devonian, Russia); Leperditellidae.

Aparchitellina domratchevi Polenova, 1955; p. 195, pl. 1, figs. 1–8 (Devonian, Russia); Leperditellidae.

Aparchites agnes Egorova, 1956; p. 107, pl. 1, figs. 1–2 (Devonian(?), Russian Platform); Leperditellidae.

Aparchites chekiangensis Hou, 1956; pp. 539, 565, pl. 3, figs. 23–26 (Upper Ordovician, Chekiang, China); Aparchitidae.

Aparchites monocornis Egorova, 1956; p. 108, pl. 1, figs. 6–11 (Devonian(?), Russian Platform); Leperditellidae.

Aparchites polenovae Egorova, 1956; p. 107, pl. 1, figs. 3–5 (Devonian(?), Russian Platform); Leperditellidae.

Bairdia angulata plana Zanina, 1956, n. var.; p. 248, pl. 8, fig. 2a–b (Lower Carboniferous, Visean, Russia); Bairdiidae.

Bairdia aptis Polenova, 1955; p. 233, pl. 11, fig. 4a–b (Devonian, Russia); Bairdiidae.

Bairdia holuschurmensis angulata Polenova, 1955, n. var.; p. 236, pl. 12, fig. 4a–b (Devonian, Russia); Bairdiidae.

Bairdia holuschurmensis holuschurmensis Polenova, 1955, n. sp., n. var.; p. 235, pl. 12, fig. 1a–b (Devonian, Russia); Bairdiidae.

Bairdia jonesi adiposa Zanina, 1956, n. var.; p. 248, pl. 8, fig. 1a–b (Lower Carboniferous, Visean, Russia); Bairdiidae.

Bairdia kirinae Zanina, 1956; p. 249, pl. 8, fig. 3 (Lower Carboniferous, Visean, Russia); Bairdiidae.

Bairdia rara Polenova, 1955; p. 230, pl. 11, fig. 1a–b (Devonian, Russia); Bairdiidae.

Bairdia navicula Martinova, 1955, in Polenova, 1955; p. 232, pl. 11, fig. 3a–b (Devonian, Russia); Bairdiidae.

Balantoides nudilobatus Zanina, 1956; p. 212, pl. 3, fig. 10a–b (Lower Carboniferous, Visean, Russia); Drepanellidae.

Bolbina rakverensis Sarv, 1956; p. 33, pl. 2, figs. 1–4 (Upper Ordovician, Estonia); Primitiidae.

Bythocypris longula Hou, 1956; pp. 553, 589, pl. 3, figs. 19–20 (Upper Ordovician, Chekiang, China); Bairdiidae.

Cambria sibirica Netskaia and Ivanova, 1956; p. 1096, text-fig. 1a–d (Lower Cambrian, Siberia); Leperditiidae.

Carbonita grandis Polenova, 1955; p. 225, pl. 9, fig. 4a–b (Devonian, Russia); Healdiidae.

Carbonita protracta Zanina, 1956; p. 246, pl. 7, fig. 10a–b (Lower Carboniferous, Visean, Russia); Healdiidae.

Cavellina clara Polenova, 1955; p. 217, pl. 7, figs. 3–4 (Devonian, Russia); Kloedenellidae.

Cavellina explicata Egorova, 1956; p. 114, pl. 2, figs. 1–2 (Devonian(?), Russian Platform); Kloedenellidae, Cavellininae.

Cavellina indistincta Polenova, 1955; p. 215, pl. 7, figs. 7–8 (Devonian, Russia); Kloedenellidae.

Cavellina informa Zanina, 1956; p. 210, pl. 3, fig. 4a–b (Lower Carboniferous, Visean, Russia); Kloedenellidae, Cavellininae.

Cavellina vilvaensis Polenova, 1955; p. 216, pl. 7, figs. 5–6 (Devonian, Russia); Kloedenellidae.

Ceratopsis granulata Sarv, 1956; p. 36, pl. 1, figs. 12–15 (Upper Ordovician, Estonia); Tetradellidae.

Clithrocytheridea? iuglandiformis Klingler, 1955*a*; p. 194, pl. 9, fig. 7d–f; pl. 10, fig. 7a–c (Upper Jurassic, Germany); Cytheridae.

Clithrocytheridea? steghausi Klingler, 1955*b*; p. 575 [pl. 10, fig. 8a–d, of Klingler, 1955*a*] (Upper Jurassic, Germany); (previously (1955*a*) proposed as a new name; see below).

Coeloenella testata Polenova, 1955; p. 202, pl. 3, fig. 5a–c (Devonian, Russia); Primitiopsidae.

Ctenobolbina perita Sarv, 1956; p. 37, pl. 2, figs. 11–13 (Upper Ordovician, Estonia); Tetradellidae.

Cyprideis? iberiacus Grékoff and Deroo, 1956; pp. 219, 228, pl. 47, figs. 29–31 (Upper Cretaceous, transition from Cenomanian to Turonian, northern Spain).

Cythereis picofrentensis Grékoff and Deroo, 1956; pp. 222, 230, pl. 47, figs. 36–37 (Upper Cretaceous, Cenomanian, northern Spain).

Cythereis soriensis Grékoff and Deroo, 1956; pp. 223, 231, pl. 47, figs. 38–39 (Upper Cretaceous, lower Cenomanian, northern Spain).

Cytherelloidea undulata Klingler, 1955*a*; p. 200, pl. 11, fig. 12a–e (Upper Jurassic, Germany); Cytherellidae.

Cytheropteron ruggierii Pucci, 1955; p. 170, pl. 1, fig. 56, text-fig. 2 (Pleistocene, Italy).

Cytherura ruggierii Pucci, 1955; p. 167, pl. 1, figs. 3–4, text-fig. 1 (Pleistocene, Italy).

Entomozoe (Nehdentomis) accurata Polenova, 1955; p. 248, pl. 15, figs. 1, 2a–b (Devonian, Russia); Entomozoidae.

Entomozoe (Richteria) distincta Polenova, 1955; p. 243, pl. 13, figs. 1–2 (Devonian, Russia); Entomozoidae.

Entomozoe (Nehdentomis) expressa Polenova, 1955; p. 251, pl. 13, fig. 3 (Devonian, Russia); Entomozoidae.

Entomozoe (Nehdentomis) nisvensis Polenova, 1955; p. 252, pl. 14, fig. 5 (Devonian, Russia); Entomozoidae.

Entomozoe (Nehdentomis) rotundata Polenova, 1955; p. 249, pl. 14, figs. 2–3 (Devonian, Russia); Entomozoidae.

Entomozoe (Richteria) sarailensis Polenova, 1955; p. 246, pl. 14, fig. 1 (Devonian, Russia); Entomozoidae.

Entomozoe (Richteria) scabrosa Polenova, 1955; p. 242, pl. 15, fig. 5a–b (Devonian, Russia); Entomozoidae.

Entomozoe (Richteria) sp. aff. *spiralis* Martinova, 1955, in litt., in Polenova, 1955; p. 245, pl. 13, fig. 4 (Devonian, Russia); Entomozoidae.

Entomozoe (Nehdentomis) triangula Polenova, 1955; p. 247, pl. 14, fig. 4 (Devonian, Russia); Entomozoidae.

Euprimitia chekiangensis Hou, 1956; pp. 548, 581, pl. 2, figs. 40–46 (Upper Ordovician, Chekiang, China); Primitiidae.

Evlanella fregis Polenova, 1955; p. 211, pl. 5, figs. 10–12 (Devonian, Russia); Kloedenellidae.

Franklinella jaregae Martinova, 1955, in Polenova, 1955; p. 254, pl. 15, figs. 3, 4a (Devonian, Russia); Entomozoidae.

Glyptopleura protvae Zanina, 1956; p. 208, pl. 2, fig. 4 (Lower Carboniferous, Visean, Russia); Kloedenellidae, Glyptopleurinae.

Gravia (Selebratina) variolata Zanina, 1956; p. 195, pl. 1, fig. 5a–b (Lower Carboniferous, Visean, Russia); Acronotellidae.

Gravia (Selebratina) variolata kalugaensis Zanina, 1956, n. var.; p. 196, pl. 1, fig. 6 (Lower Carboniferous, Visean, Russia); Acronotellidae.

Haploprimitia oanduensis Sarv, 1956; p. 33, pl. 1, figs. 7–8 (Upper Ordovician, Estonia); Primitiidae.

Haploprimitia subquadrata Hou, 1956; p. 544, p. 73, pl. 1, figs. 21–23 (Middle or Upper Ordovician, Chekiang, China); Primitiidae.

Healdia vitiligata Zanina, 1956; p. 245, pl. 7, fig. 4a–b (Lower Carboniferous, Visean, Russia); Healdiidae.

Healdianella? costata Polenova, 1955; p. 223, pl. 7, fig. 1a–b (Devonian, Russia); Healdiidae.

Healdianella inclinata Polenova, 1955; p. 224, pl. 10, fig. 3a–b (Devonian, Russia); Healdiidae.

Healdianella zolnensis Polenova, 1955; p. 224, pl. 10, fig. 7a–b (Devonian, Russia); Healdiidae.

Hollinella sokolovi laticlivosa Zanina, 1956, n. var.; p. 214, pl. 3, figs. 8–9 (Lower Carboniferous, Visean, Russia); Hollinidae.

Indivisia? schigrovskiensis Polenova, 1955; p. 220, pl. 5, figs. 1–3 (Devonian, Russia); Kloedenellidae.

Janischewskya digitata mulita Zanina, 1956, n. var.; p. 216, pl. 3, fig. 7 (Lower Carboniferous, Visean, Russia); Hollinidae.

Janischewskya longiuscula Zanina, 1956; p. 217, pl. 3, fig. 6 (Lower Carboniferous, Visean, Russia); Hollinidae.

Jonesina bivesiculosa profusa Zanina, 1956, n. var.; p. 201, pl. 2, fig. 7a–b (Lower Carboniferous, Visean, Russia); Kloedenellidae, Perprimitiinae.

Kellettina difluxa Zanina, 1956; p. 241, pl. 7, figs. 1–2 (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Kellettina legibilis Zanina, 1956; p. 240, pl. 6, figs. 10a–b, 11 (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Kirkbya minuta Zanina, 1956; p. 226, pl. 5, fig. 3 (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Kirkbya pristina Zanina, 1956; p. 226, pl. 5, fig. 2 (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Kirkbyella? undulata Zanina, 1956; p. 227, pl. 5, fig. 4 (Lower Carboniferous, Visean, Russia); Kirkbyidae.

Klieana? pustulata Klingler, 1955*a*; p. 204, pl. 12, fig. 15a–e (Upper Jurassic, Germany); Cytheridae.

Knoxiella inserica Polenova, 1955; p. 212, pl. 5, figs. 4–9 (Devonian, Russia); Kloedenellidae.

Leperditella prima Sarv, 1956; p. 31, pl. 2, figs. 5–7 (Upper Ordovician, Estonia); Leperditellidae.

Leperditellina abunda Polenova, 1955; p. 198, pl. 4, figs. 4–5 (Devonian, Russia); Primitiopsidae.

Leperditellina? crassa Polenova, 1955; p. 200, pl. 4, figs. 1–3 (Devonian, Russia); Primitiopsidae.

Leperditellina miranda Polenova, 1955; p. 199, pl. 3, figs. 1–2 (Devonian, Russia); Primitiopsidae.

Leptocythere multipunctata transiens Pucci, 1955, n. subsp.; p. 166, pl. 1, fig. 1, text-fig. 3 (Pleistocene, Italy).

Macrodentina ornata Klingler, 1955*a*; p. 191, pl. 8, fig. 5a–b, f–g; pl. 9, fig. 5c–e (Upper Jurassic, Germany); Cytheridae.

Macrodentina perforata Klingler, 1955*a*; p. 190, pl. 7, fig. 4a–e; pl. 8, fig. 4f (Upper Jurassic, Germany); Cytheridae.

Macrodentina sculpta Klingler, 1955*a*; p. 188, pl. 6, fig. 3a; pl. 7, fig. 3b–g (Upper Jurassic, Germany); Cytheridae.

Marginia lobanovoensis Polenova, 1955; p. 213, pl. 6, figs. 6–8 (Devonian, Russia); Kloedenellidae.

Marginia? radiata Egorova, 1956; p. 113, pl. 2, figs. 7, 9 (Devonian(?), Russian Platform); Kloedenellidae, Knoxinae [*sic*].

Mennerella crassa Egorova, 1956; p. 111, pl. 2, figs. 3–6 (Devonian?, Russian Platform); Kloedenellidae, Kloedenellinae.

Metacypris verrucosa Klingler, 1955*a*; p. 206, pl. 12, fig. 17a; pl. 13, fig. 17b–d (Upper Jurassic, Germany); Cytheridae, Xestoleberinae.

Microcheilinella affinis Polenova, 1955; p. 229, pl. 9, fig. 3a–c (Devonian, Russia); Healdiidae.

Microcheilinella kordonica Polenova, 1955; p. 226, pl. 8, fig. 4a–b (Devonian, Russia); Healdiidae.

Microcheilinella larionovae Polenova, 1955; p. 227, pl. 9, fig. 2a–b (Devonian, Russia); Healdiidae.

Microcheilinella notabilis Polenova, 1955; p. 228, pl. 9, fig. 1a–c (Devonian, Russia); Healdiidae.

Microcoeloenella optata Polenova, 1955; p. 203, pl. 10, figs. 8a–b, 9 (Devonian, Russia); Primitiopsidae.

Microcoeloenella optata curta Polenova, 1955, n. var.; p. 204 (Devonian, Russia); Primitiopsidae.

Monoceratina sinuata Posner, in Zanina, 1956; p. 194, pl. 1, fig. 3 (Lower Carboniferous, Visean, Russia); Acronotellidae.

Octonaria chekiangensis Hou, 1956; pp. 552, 588, pl. 3, figs. 15–17 (Upper Ordovician, Chekiang, China); Thlipsuridae.

Orthonotacythere hauteriviana Bartenstein, 1956; p. 532, pl. 3, figs. 80–81 (Lower Cretaceous, England); Cytheridae.

Orthonotacythere roemeri Bartenstein, 1956; p. 531, pl. 3, figs. 76–77 (Lower Cretaceous, England); Cytheridae.

Paraparchites porrectus Zanina, 1956; p. 192, pl. 1, fig. 1a–b (Lower Carboniferous, Visean, Russia); Leperditellidae.

Paraschmidtella? granopunctata Hou, 1956; pp. 541, 568, pl. 4, figs. 1–4 (Upper Ordovician, Chekiang, China); Aparchitidae.

Paraschmidtella hexapunctata Hou, 1956; pp. 542, 569, pl. 4, figs. 5–7 (Upper Ordovician, Chekiang, China); Aparchitidae.

Paraschmidtella micropunctata Hou, 1956; pp. 542, 570, pl. 4, figs. 8–12 (Middle or Upper Ordovician, Chekiang, China); Aparchitidae.

Parulrichia minima Sarv, 1956; p. 38, pl. 1, figs. 17–18 (Upper Ordovician, Estonia); Drepanellidae.

Pinnatulites triangularis Hou, 1956; pp. 540, 566, pl. 1, figs. 1–6 (Lower Ordovician, Chekiang, China); Aparchitidae.

Platybolbina temperata Sarv, 1956; p. 39, pl. 2, figs. 8–10 (Upper Ordovician, Estonia); Eurychilinidae.

Pleurocythere? rodewaldensis Klingler, 1955*a*; p. 198, pl. 10, fig. 10a–c; pl. 11, fig. 10d (Upper Jurassic, Germany); Cytheridae.

Primitia arcuata Hou, 1956; pp. 546, 577, pl. 2, figs. 25–28 (Middle Ordovician, Chekiang, China); Primitiidae.

Primitia bicostata Hou, 1956; pp. 545, 575, pl. 2, figs. 10–12 (Upper Ordovician, Chekiang, China); Primitiidae.

Primitia chekiangensis Hou, 1956; pp. 545, 576, pl. 2, figs. 17–24 (Middle Ordovician, Chekiang, China); Primitiidae.

Primitia? dorsotuberosa Hou, 1956; pp. 546, 574, pl. 2, figs. 37–39 (Middle Ordovician, Chekiang, China); Primitiidae.

Primitia? microtuberosa Hou, 1956; pp. 544, 574, pl. 2, figs. 5–8 (Upper Ordovician, Chekiang, China); Primitiidae.

Primitia rava Sarv, 1956; p. 32, pl. 1, figs. 1–4 (Upper Ordovician, Estonia); Primitiidae.

Primitia symmetrica Hou, 1956; pp. 546, 578, pl. 2, figs. 29–35 (Middle Ordovician, Chekiang, China); Primitiidae.

Primitiella longa Sarv, 1956; p. 34, pl. 1, figs. 9–11 (Upper Ordovician, Estonia); Primitiidae.

Primitiella magna Sarv, 1956; p. 35, pl. 1, figs. 5–6 (Upper Ordovician, Estonia); Primitiidae.

Pseudonodellina rotundata Polenova, 1955; p. 206, pl. 10, fig. 4a–b (Devonian, Russia); Drepanellidae.

Pseudonodellina strelniensis Polenova, 1955; p. 205, pl. 10, fig. 5a–b (Devonian, Russia); Drepanellidae.

Scabriculocypris goerlichi Klingler, 1955*a*; p. 185, pl. 6, fig. 1a–e (Upper Jurassic, Germany).

Scrobicula concentralis Zanina, 1956; p. 222, pl. 4, figs. 5a–b, 7 (Lower Carboniferous, Visean, Russia); Scrobiculidae.

Scrobicula eresiformis Zanina, 1956; p. 221, pl. 4, fig. 8a–b (Lower Carboniferous, Visean, Russia); Scrobiculidae.

Scrobicula foveolata Zanina, 1956; p. 224, pl. 4, fig. 3a–c (Lower Carboniferous, Visean, Russia); Scrobiculidae.

Scrobicula monospinosa Zanina, 1956; p. 223, pl. 4, fig. 4a–c (Lower Carboniferous, Visean, Russia); Scrobiculidae.

Scrobicula scrobiculata corrugata Zanina, 1956, n. var.; p. 219, pl. 4, fig. 6a–c (Lower Carboniferous, Visean, Russia); Scrobiculidae.

Sphaeromicola cirolanae Rioja, 1951; p. 170, pls. 1–2 (Recent, Mexico).

Tetradella? kosvaensis Polenova, 1955; p. 209, pl. 6, figs. 2–5 (Devonian, Russia); Tetradellidae.

Uchtovia? egorovi Polenova, 1955; p. 214, pl. 7, fig. 2a–b (Devonian, Russia); Kloedenellidae.

Ulrichia chekiangensis Hou, 1956; pp. 550, 584, pl. 2, figs. 4–7 (Upper Ordovician, Chekiang, China); Drepanellidae, Ulrichinae.

Zygobeyrichia insignis Egorova, 1956; p. 110, pl. 1, figs. 12–13 (Devonian(?), Russian Platform); Zygobolbidae.

SUPPLEMENT TO NEW NAMES IN 1955

Clithrocytheridea? steghausi Klingler, 1955*a*; p. 196, pl. 10, fig. 8a–d (improperly proposed as a new name for *Clithrocytheridea lineata* (Martin) of Steghaus, 1951, pp. 215–217, pl. 15, fig. 32 (not *Macrodentina lineata* Martin, 1940); Klingler (1955*b*) correctly proposed this name as a new species; see above).

SUPPLEMENT TO FORMS WITH NOMENCLATURA APERTA IN 1950–1956

Aechmina sp., Hou, 1956; pp. 551, 586, pl. 3, fig. 10 (Middle or Upper Ordovician, Chekiang, China); Aechminidae.

Aparchites sp., Hou, 1956; pp. 540, 565, pl. 3, figs. 21–22 (Middle Ordovician, Chekiang, China); Aparchitidae.

Bairdia sp. *1*, Grékoff and Deroo, 1956; p. 218, pl. 46, figs. 7–8 (Upper Cretaceous, Cenomanian to Turonian, northern Spain).

Bairdia? sp., Klingler, 1955*a*; p. 187, pl. 6, fig. 2a–b (Upper Jurassic, Germany).

Bairdia? sp., Hou, 1956; pp. 553, 588, pl. 3, fig. 18 (Middle Ordovician, Chekiang, China); Bairdiidae.

Bythocypris sp. *1*, Grékoff and Deroo, 1956; p. 218, pl. 46, figs. 3–4 (Upper Cretaceous, Cenomanian, northern Spain).

Bythocypris sp. *A*, Hou, 1956; pp. 554, 590, pl. 3, fig. 27 (Middle Ordovician, Chekiang, China); Bairdiidae.

Bythocypris sp. *B*, Hou, 1956; pp. 554, 590, pl. 4, figs. 24–25 (Upper Ordovician, Chekiang, China); Bairdiidae.

Candona? n. sp., Swain, 1956; p. 136, pl. 3, fig. 12a–b (Paleocene, Utah); Cyprididae, Candoninae.

Candona n. sp., Swain, 1956; p. 136, pl. 3, fig. 13a–b (Paleocene to Eocene, Colorado and Utah); Cyprididae, Candoninae.

Ctenobolbina sp., Hou, 1956; pp. 551, 586, pl. 3, figs. 11–13 (Upper Ordovician, Chekiang, China); Hollinidae.

Cyprideis sp., Choczewski, 1955; p. 65, pl. 2, fig. 3 (Upper Miocene, Poland); Cytheridae.

Cypris? sp., Ludbrook, 1956; p. 42, pl. 1, figs. 7–8 (Pleistocene? to Recent, Australia); Cyprididae.

Cypris pagei var., Swain, 1956; p. 135, pl. 3, fig. 8a–c (Paleocene, Colorado); Cyprididae, Cypridinae.

Cyprois n. sp., Swain, 1956; p. 135, pl. 3, fig. 5a–j (Paleocene, Colorado and Utah); Cyprididae, Cypridinae.

Cythereis sp. *1*, Grékoff and Deroo, 1956; p. 224, pl. 47, figs. 42–43 (Upper Cretaceous, upper Cenomanian, northern Spain).

Cythereis sp. *2*, Grékoff and Deroo, 1956; p. 224, pl. 47, fig. 44 (Upper Cretaceous, transition from Cenomanian to Turonian, northern Spain).

Cythereis sp., Choczewski, 1955; p. 71, pl. 3, fig. 1 (Upper Miocene, Poland); Cytheridae.

Cythereis sp., Choczewski, 1955; p. 70, pl. 2, fig. 13a–b (Upper Miocene, Poland); Cytheridae.

Cytheridea sp., Choczewski, 1955; p. 66, pl. 2, fig. 7 (Upper Miocene, Poland); Cytheridae.

Cytheropteron sp., Bartenstein, 1956; pp. 530–531, pl. 3, fig. 69 (Lower Cretaceous, England); Cytheridae.

Drepanella sp., Hou, 1956; pp. 550, 583, pl. 3, figs. 2–3 (Upper Ordovician, Chekiang, China); Drepanellidae.

Erpetocypris? sp., Swain, 1956; p. 136, pl. 3, fig. 6a–b (Paleocene to Eocene, Colorado and Utah); Cyprididae, Cypridinae.

Eucytherura sp., Choczewski, 1955; p. 77, pl. 3, fig. 10 (Upper Miocene, Poland); Cytheridae.

Euprimitia, sp. Hou, 1956; pp. 549, 582, pl. 2, fig. 47 (Middle Ordovician, Chekiang, China); Primitiidae.

Hemicythere sp., Choczewski, 1955; p. 69, pl. 2, fig. 11 (Upper Miocene, Poland); Cytheridae.
Heterocypris n. sp. and var., Swain, 1956; p. 135, pl. 3, fig. 2a–c (Paleocene, Colorado); Cyprididae, Cypridinae.
Heterocypris n. sp., Swain, 1956; p. 134, pl. 3, fig. 1a–c (Eocene, Colorado and Utah); Cyprididae, Cypridinae.
Heterocypris? sp., Swain, 1956; p. 134, pl. 3, fig. 3a–b (Eocene, Colorado); Cyprididae, Cypridinae.
Limnocythere sp., Swain, 1956; p. 137, pl. 3, fig. 17 (Eocene, Colorado); Cytheridae.
Metacypris n. sp., Swain, 1956; p. 137, pl. 3, fig. 15a–e (Paleocene, Colorado); incertae sedis.
Metacypris? sp., Klingler, 1955*a*; p. 202, pl. 12, fig. 14a–c (Upper Jurassic, Germany); Cytheridae, Xestoleberinae.
Metacypris n. sp.(?), Marlière, 1956; p. 48, text-fig. 2 (Jurassic, Belgian Congo).
Paracypris sp. *1*, Grékoff and Deroo, 1956; p. 217, pl. 46, figs. 15–16 (Upper Cretaceous, Cenomanian, northern Spain).
Pinnatulites sp., Hou, 1956; pp. 541, 567, pl. 1, figs. 7–9 (Lower Ordovician, Chekiang, China); Aparchitidae.
Pontocypris? sp. *1*, Grékoff and Deroo, 1956; p. 217, pl. 46, figs. 13–14 (Upper Cretaceous, Cenomanian, northern Spain).
Potamocypris n. sp., Swain, 1956; p. 136, pl. 3, figs. 9a–e, 10 (Paleocene, Colorado); Cyprididae, Cypridopseinae.
Potamocypris n. sp. and var., Swain, 1956; p. 136, pl. 3, fig. 11a–d (Paleocene, Colorado); Cyprididae, Cypridopseinae.
Primitia sp. *A*, Hou, 1956; pp. 547, 578, pl. 2, figs. 1–4 (Upper Ordovician, Chekiang, China); Primitiidae.
Primitia sp. *B*, Hou, 1956; pp. 547, 579, pl. 2, fig. 9 (Upper Ordovician, Chekiang, China); Primitiidae.
Primitia sp. *C*, Hou, 1956; pp. 548, 580, pl. 2, figs. 13–16 (Upper Ordovician, Chekiang, China); Primitiidae.
Primitia? sp. *D*, Hou, 1956; pp. 548, 580, pl. 2, fig. 36 (Middle Ordovician, Chekiang, China); Primitiidae.
Primitiella sp. (type *A*), Hou, 1956; pp. 542, 570, pl. 1, figs. 10–12 (Lower Ordovician, Chekiang, China); Primitiidae.
Primitiella sp. (type *B*), Hou, 1956; pp. 543, 571, pl. 1, figs. 13–18 (Lower Ordovician, Chekiang, China); Primitiidae.
Primitiella? sp., Hou, 1956; pp. 544, 572, pl. 1, fig. 20 (Upper Ordovician, Chekiang, China); Primitiidae.
Thlipsurella sp., Hou, 1956; pp. 552, 587, pl. 3, fig. 14 (Upper Ordovician, Chekiang, China); Thlipsuridae.
Ulrichia sp., Hou, 1956; pp. 551, 585, pl. 3, figs. 8–9 (Upper Ordovician, Chekiang, China); Drepanellidae, Ulrichiinae.
Winchellatia? sp., Hou, 1956; pp. 549, 583, pl. 3, fig. 1 (Middle Ordovician, Chekiang, China); Primitiidae, Eurychilininae.
Gen. et sp. indet. Nr. 3, Klingler, 1955*a*; p. 193, pl. 8, fig. 6a, d; pl. 9, fig. 6b–c (Upper Jurassic, Germany); Cytheridae.
Gen. et sp. indet. Nr. 8, Klingler, 1955*a*; p. 205, pl. 12, fig. 16a–b (Upper Jurassic, Germany); Cytheridae.
Gen. et sp. *A* (indet.), Hou, 1956; pp. 555, 591, pl. 4, figs. 13–16, 23 (Middle Ordovician, Chekiang, China).
Gen. et sp. *B* (indet.), Hou, 1956; pp. 555, 591, pl. 4, figs. 17–18 (Upper Ordovician, Chekiang, China).
Gen. et sp. *C* (indet.), Hou, 1956; pp. 554, 592, pl. 4, figs. 19–22 (Upper Ordovician, Chekiang, China).
PODOCOPA sp., Grékoff and Deroo, 1956; pp. 225, 231, pl. 47, figs. 25–28 (Upper Cretaceous, Cenomanian, northern Spain).

SUPPLEMENT TO NOMINA NUDA IN 1954

Huarpeana Rusconi, 1954 *(nomen nudum)* [*H. oblonga* Rusconi, 1954]; p. 3 (Ordovician, Argentina).
Huarpeana oblonga Rusconi, 1954 *(nomen nudum)*; p. 3 (Ordovician, Argentina).
Balticella? serrana Rusconi, 1954 *(nomen nudum)*; p. 3 (Ordovician, Argentina).

CORRECTIONS

Amygdalella Martinsson, 1956, previously listed (Levinson, 1957, pp. 372, 376) as "*Amygalella*" Martinsson. In the original reference (Martinsson, 1956*a*, p. 31), the generic name was misspelled in the heading of the description, but the obvious intent throughout the paper was to spell the generic name as noted above.

news reports

AUSTRALIA

IRENE CRESPIN

The thirty-third meeting of the Australian and New Zealand Association for the Advancement of the Science was held at Adelaide, South Australia, from August 20 to 27, 1958. Geologists and palaeontologists from all parts attended the many interesting sessions of Section C. Amongst the visitors was Professor Harold Wanless, of the University of Illinois. Contributions on palaeontology were limited to short papers, but interesting reports on stratigraphic problems were included in some of the Symposia. The writer gave a summary of the importance of foraminifera in Australian Permian stratigraphy. A. N. Carter, of the Geological Survey of Victoria, discussed the value of pelagic foraminifera in the Tertiary deposits of western Victoria and of the Murray Basin of South Australia. He recognises eleven faunal units characterised by pelagic foraminifera in beds of Upper Eocene to Middle Miocene age. Dr. N. H. Ludbrook spoke on the Tertiary stratigraphy of the Murray Basin, basing her evidence primarily on foraminifera. Dr. M. F. Glaessner contributed many interesting comments to discussions. He presented a short paper on "New fossils from the base of the Cambrian in South Australia." Excursions were organised to the Eocene and Oligocene deposits at Aldinga and to the Lower Miocene deposits at Murray Bridge.

The activities of micropalaeontologists in Australia now cover a wide field:

Foraminifera: A Bulletin by the writer, entitled "Permian foraminifera of Australia," has just been issued. Fifty-two new species and four new genera are described in this work. A recent discovery of considerable interest is that of a rich assemblage of arenaceous foraminifera, associated with abundant conodonts, in the Upper Devonian of Western Australia.

With the recent discovery of oil in Papua, the micropalaeontological examination of bore cores in this region has become of primary importance. D. J. Belford supervises the study of the foraminifera in the Papuan and New Guinea deposits for the Bureau of Mineral Resources, Canberra. He has recently published a paper on a new genus of foraminifera from the Upper Cretaceous of Western Australia, and is preparing a Bulletin on the Upper Cretaceous foraminifera of Western Australia.

Mary Wade, of the University of Adelaide, is associated with Dr. Glaessner in a morphologic study of planktonic foraminifera. A. N. Carter, of Melbourne, is continuing his investigations on the Tertiary foraminifera of western Victoria.

Conodonts: Dr. B. F. Glenister, of the University of Western Australia, is engaged in a study of conodont assemblages from the Devonian and Carboniferous deposits of Western Australia. Many thousands of specimens are available for this work.

Ostracoda: P. J. Jones, of the Bureau of Mineral Resources, is studying the Lower Carboniferous and Upper Devonian Ostracoda of the Fitzroy and Bonaparte Gulf Basins of Western Australia. This work involves examination of the ostracode assemblages found in type surface sections; many of these assemblages are proving useful in subsurface correlations.

Microplankton: Dr. P. R. Evans, of the Bureau of Mineral Resources, is undertaking the first search for microplankton in the Palaeozoic rocks of Australia. He has already found rich assemblages of hystrichospherids and Chitinozoa in subsurface sections in Western Australia.

Spores and pollen: B. E. Balme, of the University of Western Australia, is continuing his study of the pollen and spores of the Palaeozoic sediments of Western Australia. The results of his work are proving of considerable value in connection with subsurface deposits of Permian age.

IRENE CRESPIN
Bureau of Mineral Resources
Canberra

AUSTRIA

RUDOLF GRILL

Once again, Austrian paleontology has suffered a severe loss. On June 21, 1958, Hofrat C. A. Bobies, whose studies on Bryozoa were widely known and have been previously

mentioned in this column, passed away quite unexpectedly, at the age of sixty. Bobies published his first paleontological paper in 1924 ("Bryozoa-bearing upper Sarmatian near Kalch," Austria, Geol. Bundesanst., Verh.). In 1928, a publication on the Bryozoa-bearing sediments of the Inner-Alpine Vienna Basin followed (Geol. Ges. Wien, Mitt., vol. 21). Because Bobies held highly responsible positions and therefore had to carry on his research work in his spare time, further publications appeared only after his retirement. In 1956, he reported on the bryozoan fauna of the Tortonian littoral deposits of Kalksburg, near Vienna (Austria, Geol. Bundesanst., Jahrb., vol. 99, pp. 225–258, 4 pls.). In 1957, a detailed paper on the Bryozoa of the Austrian Sarmatian was published (ibid., vol. 100, pp. 81–114, 4 pls.), and finally, in 1958, a monograph on the Crisiidae of the Tortonian of the Vienna Basin appeared (ibid., vol. 101, pp. 147–165, 3 pls.).

In addition to papers on paleontological subjects, Bobies published a number of valuable studies on specialized aspects of the Tertiary of Austria. At the time of his death, he had many other plans for future work. His achievements have earned Bobies a permanent place of honor in our branch of science.

The following micropaleontological activities took place in Austria during 1958:

Edith Kristan (University of Vienna, Geological Institute) and R. Oberhauser (Geological Survey of Austria continued their micropaleontological investigations on the Alpine Triassic. Oberhauser published a report of silicification in a Triassic *Trocholina* from a locality near Vienna (Austria, Geol. Bundesanst., Verh., 1958, p. 295).

Another publication by Oberhauser, based on abundant Upper Cretaceous and Paleogene foraminiferal faunas, is a fundamental contribution to the clarification of some geologic problems ("Neue Beiträge zur Geologie und Mikropaläontologie der Hohen Kugel, Vorarlberg," Austria, Geol. Bundesanst., Verh., 1957, pp. 121–140). In the micropaleontological section of B. Plöchinger's paper entitled "Das Molasseprofil längs der Bregenzer Ach und des Wirtatobels" (1958, Austria, Geol. Bundesanst., Jahrb., vol. 101), Oberhauser has reported on allochthonous foraminifera from the Cretaceous and Eocene occurring in the Lower Freshwater Molasse (Chattian-Aquitanian) of western Austria (Vorarlberg), as well as on sparse autochthonous foraminiferal faunas from the Upper Marine Molasse (Burdigalian) of the same area.

A brief supplement to E. Kristan's paper entitled "Ophthalmidiidae und Tetrataxinae (Foraminifera) aus dem Rhät der Hohen Wand in Niederösterreich" (ibid., vol. 100) mentioned in last year's report has been published. New names are proposed for two genera Austria, Geol. Bundesanst., Verh., 1958, p. 114).

A. Papp, of the Paleontological Institute of the University of Vienna, has published a paper on the occurrence and distribution of the Upper Eocene in Austria (1958, Geol. Ges. Wien, Mitt., vol. 50, pp. 251–269, 2 pls.). From a number of surface outcrops and from wells in the Molasse zone of Upper Austria, he has described several species of *Nummulites (Nummulites variolarius variolarius, N. variolarius* subsp. *2, N. chavannesi, N. bouillei*, and *N. ramondiformis*). The possibility of morphologic separation of the forms of *N. variolarius* as a means of making further stratigraphic subdivisions is discussed. Additional data on the same subject were presented by Papp in a paper read at the meeting of the Geological Society of Vienna, which celebrated the 50th anniversary of its founding in September, 1958.

Further data on the Eocene in the new wells in Upper Austria were presented by F. Aberer (Rohoel-Gewinnungs A.G.) in a paper summarizing the geology of the Molasse zone in western Upper Austria and in Salzburg (1958, Geol. Ges. Wien, Mitt., vol. 50, pp. 23–93). The Mesozoic, Paleogene, and Neogene components of the basin sediments were described in detail. K. Gohrbant, Inge Küpper, and W. Schors also made important contributions to this study by establishing a micropaleontological basis for the stratigraphic subdivision.

The previous news report by this correspondent mentioned certain studies on the Molasse window of Rogatsboden, in the Lower Austrian Flysch zone, and indicated that the ostracodes were being studied by K. Kollmann (Rohoel-Gewinnungs A.G.). Kollmann has since published a preliminary report on the ostracode fauna of the Inner-Alpine Molasse of Rogatsboden (Austria, Geol. Bundesanst., Verh., 1958, pp. 31–38). The predominance of Lower to Middle Oligocene over Upper Oligocene species, as well as the absence of typical Eocene forms, indicates that the beds from which the ostracodes were collected (Lithothamnium marl) are of Lower to Middle Oligocene age. Ecologically, the fauna, comprising at least twenty-five species, points without exception to a marine biotope and, for the most part, to rather shallow water.

In connection with an investigation by H. Küpper on the Neogene between Grinzing and Nussdorf in Vienna (1958, Austria, Geol. Bundesanst., Jahrb., vol. 101, pp. 117–138), K. Kollmann determined the ostracodes of the Sarmatian and Pannonian beds, adding some comments on a number of taxionomic questions. In the same paper, the general stratigraphic interpretation was contributed by the present writer. Another paper by R. Grill, concerning the geology of the Outer-Alpine Vienna Basin (Austria, Geol. Bundesanst., Verh., 1958, pp. 43–54), deals, among other topics, with a revised stratigraphic classification of the "Grund" beds, which are highly important in the stratigraphy of the Miocene.

A stratigraphic survey of the southeastern part of the Vienna Basin was carried out by A. Tollmann, of the Geological Institute of the University of Vienna (1955, Wiss. Arb. Burgenland, no. 10, pp. 1–74),

including seven lists of foraminifera and ostracodes, together with geologic maps and sections. This resurvey of the Neogene of the southwestern slope of the Leitha Mountains is based chiefly on micropaleontology. The basin and marginal facies are correlated by this means.

A paper by G. Kopetzky, on the Miocene of the Graz Basin, has been published (1957, Austria, Landesmus. Joanneum, Mus. Bergbau, Geol. und Technik, Mitt., Graz, pp. 1–112). In that paper also, the stratigraphy is based chiefly on micropaleontology. The paper contains a list of foraminifera and several maps.

Under the title "*Schackoinella*, a new genus of foraminifera," R. Weinhandl has published a note on a new foraminiferal form from the lower Sarmatian of the Vienna Basin. The test shows a distinctly trochospiral *Globigerina*-like structure, with a circular, open umbilicus, and a single moderately long spine (projecting at an oblique angle or straight out) on most of the chambers. The genotype is *Schackoinella sarmatica* Weinhandl (Austria, Geol. Bundesanst., Verh., 1958, pp. 141–142, 1 text-fig.).

With the first publication on fossil Discoasteridae in Austria, H. Stradner (Paleontological Institute, University of Vienna) is setting out to investigate the stratigraphic value of the Discoasteridae occurring in Austrian sediments (1958, Erdöl-Zeitschrift, Vienna, pp. 178–188, 38 text-figs.). The types so far collected from Paleogene and Neogene horizons show that distinct differences can be observed in both the occurrences and the frequencies of the various species. The material described came from Middle Miocene beds in an exploratory well drilled in the Korneuburg Basin, near Vienna. One of the samples yielded nine types of Discoasteridae, some of which were represented by numerous specimens, together with coccoliths and several specimens of *Nannoconus*. In addition to dealing with the paleontologic content of the sample, the paper also covers methods of study in great detail. E. Kamptner (Museum of Natural History, Vienna) has published a study on the systematics and phylogeny of the Dasycladaceae (Siphoneae verticillatae) (1958, Vienna Naturhist. Mus., Ann., vol. 62, pp. 95–122, 1 table).

K. Turnovsky has returned from Turkey, where he had been employed by the M.T.A. He is now working again as a micropaleontologists with the Österreichische Mineralölverwaltung A.G.

RUDOLF GRILL
Geologische Bundesanstalt
Vienna

BENELUX

J. H. VAN VOORTHUYSEN

BELGIUM

University of Louvain, Coal Museum

Dom Remacle Rome, O.S.B., Director of the Paleontological Museum of the University of Louvain, has received, from R. Conil, some highly valuable material from the lower Dinantian of the northern boundary of the Namur Basin. This material is extraordinarily rich, especially in the ostracode genus *Cryptophyllus*. So far, Dom Rome has spent a month trying to disintegrate this highly compact rock, but has not succeeded. May I repeat my request of last year that ostracode specialists give Dom Rome advice on how to disintegrate this rock, in which the ostracodes are so firmly embedded?

University of Louvain, Palynological Laboratory

Professor Dr. W. Mullenders, who is in charge of the Palynological Laboratory, has published the following papers: "La Palynologie" (Les Naturalistes Belges, vol. 38, 1957, pp. 21–37); "Palynologisch en geologisch onderzoek in de alluviale vlakte van de Dijle, te Heverlee-Leuven" (Agricultara, ser. 2, vol. 5, 1957, pp. 57–64) (in collaboration with F. Gullentops, and assisted by Miss M. Cornil); "Les pollens de *Viola tricolor* L. *tricolor* et de *Viola maritima* Schweigg." (Soc. Roy. Bot. Belgique, Bull., vol. 90, 1957, pp. 5–12 (in collaboration with E. Mullenders); "Les pollens de *Bequaertia mucronata* et *Apodostigma pallens* (Hippocrateaceae)" (Grana Palynologica, new ser., vol. 1, no. 3, 1958, pp. 75–77) (in collaboration with E. Mullenders); "Étude palynologique d'une tombelle de l'âge du bronze à Weelde (Campine)" (Soc. Roy. Bot. Belgique, Bull., vol. 90, 1958, pp. 311–313) (in collaboration with J. Mertens); and "L'oscillation de Bölling à Lommel (Campine, Belgique): Datation par le C^{14}" (Soc. Roy. Bot. Belgique, Bull., vol. 90, 1958, pp. 314–317) (in collaboration with F. Gullentops and E. Crêvecoeur).

Dr. Mullenders, together with Professor Gullentops, of the Geological Institute, is now engaged in a study of late glacial and post-glacial peat and lacustrine sediments in the depression of Leau (Brabant, Hesbaye Lumide) and peat at Molenbeek (Sette, St. Pierre). Dr. Mullenders is also investigating peats in the neighborhood of la Bar (Ardennes) and in the valley of the Aubette (Côte d'Or), both in France. Together with Dr. Leonard, of the University of Brussels, he is studying the pollen genera *Schotia* (Caesalpinieae) and *Coffea* (Rubiaceae).

University of Liège, Laboratory of Micropaleontology

The Laboratory of Professor Ubaghs has been engaged principally in a study of the Cretaceous-Tertiary boundary in the Lower Congo valley in the Cuanza basin of Angola. Pelagic foraminiferal associations have been found to be the best tool for zoning and dating formations. Discovery of the following assemblages is reported: 1) *Globorotalia*

compressa – Globigerinoides daubjergensis zone; 2) *Globorotalia angulata* zone; 3) *Globigerina – Globorotalia – Truncorotaloides* assemblage. The planktonic succession in this part of Africa appears to be exactly the same as that determined in other parts of the world by Loeblich and Tappan (1957).

Royal Belgian Institute of Natural Sciences Botanical Section, Brussels

Dr. R. Vanhoorne has published the following papers: "Les flores pléistocènes belges" (Congrès INQUA, V (Madrid-Barcelona), Res. Com., 1957, pp. 189–190); this paper contains the summary of a paper read at Madrid, concerning the Pleistocene floras of Belgium; "Quelques spectres palynologiques datant de l'époque gallo-romaine au Pays de Waas (Belgique)" (Jard. Bot. État Bruxelles, Bull., vol. 27, no. 4, 1957, pp. 685–688); this paper deals with the palynology of horizons buried since Roman times; it appears that during the Subatlanticum the beech tree was very common in the region studied.

Royal Belgian Institute of Natural Sciences Association for the Study of Carboniferous Stratigraphy

Dr. André Pastiels has published the following paper concerning the foraminifera of the Carbinoferous: "Contribution à l'étude des Foraminifera du Namurien et du Westphalien de la Belgique" (Assoc. Étude Pal. et Strat. Houillères, no. 27, 1956).

Faculté Polytechnique de Mons Département de Géologie

Professor René Marlière has published an important paper on the stratigraphic position of the Montian as indicated by ostracodes: "Ostracodes du Montien de Mons et résultats de leur étude" (Soc. Belge Géol., Mém., ser. 8, no. 5, 1958, pp. 1–53, 6 pls.). He studied a 90-meter thickness of the so-called Montian, and by means of the ostracodes he was able to distinguish: Couches à *Triginglymus* (Calcaire de Mons, sensu stricto); Couches à *Cytheretta*; and Couches à *Cytherelloidea* (Tuffeau de Ciply). Thus, he has succeeded in proving that the marine Montian is composite.

NETHERLANDS

University of Leiden

Professor van der Vlerk tells me that he is still engaged in his revision of the genus *Lepidocyclina*, in collaboration with Dr. Grimsdale. Some of Professor Flohrschütz' students are investigating peats from the Netherlands, France, and Austria. One graduate student is writing his dissertation on peat and other sediments from northern Italy. As director of the Paleobotanical Laboratory of the Government Agricultural Experiment Station at Velp, near Arnhem, Professor Flohrschütz is carrying on palynological and stratigraphic research on bottom samples furnished by the Institute of Agricultural Mapping at Wageningen. He has also analyzed material from France and Spain.

University of Utrecht

Dr. Drooger, Conservator at the Geological Institute, and his students are engaged in studies on Recent foraminifera from the Assab region (Red Sea), on Miocene foraminifera from Germany, and on Miocene-Pliocene foraminifera from Italy. In addition, he is, as always, interested in the study of the genus *Miogypsina* from various parts of Europe; at present he is working on samples from Greece and southern France. Together with Professor Socin, of Turin, he will soon publish a paper on the genus *Lepidocyclina* from the classic locality of Rosignano.

Part 4 of the Reports of the Orinoco Shelf Expedition will appear in the near future. It was written by Dr. Drooger and Mr. Kaasschieter, and is entitled "Foraminifera of the Orinoco-Trinidad-Paria shelf" (K. Nederl. Akad. Wetensch., Verh., ser. 1, Natuurk.). Mr. Kaasschieter's dissertation, "Belgian Eocene Foraminifera," is now nearly finished. J. E. van Hinte has begun an exhaustive study of the Upper Cretaceous planktonic foraminifera of the Guttaring region, Kärnten, Austria.

During 1958, Dr. Drooger published the following papers: „Das Alter der Miogypsinen-Gesteine von Kephallinia" (Athens, Univ., Lab. Géol., Ann. Géol. Pays Helléniques); and, in collaboration with R. F. Rutsch and H. J. Oertli, "Neue Helvétien-Faunen aus der Molasse zwischen Aare und Emme (Kt. Bern)" (Naturf. Ges. Bern, Mitt., new ser., vol. 16).

Dr. F. P. Jonker, Conservator of the Botanical Museum and Herbarium, informs me that C. R. Jansen's study of the history of the late glacial and Holocene vegetation of the Cretaceous district in the southern part of the Dutch Province of Limburg has yielded a number of important results. This study will probably be published during 1959. A. A. Manten's pollen-analytical study of the Lower Miocene lignite in the Anna quarry at Haanrade (Limburg) will appear very soon (Acta Bot. Neerl., vol. 7, no. 3). The study of this lignite will be extended by an investigation of the fruits, seeds, and wood, which are present in great quantities. R. Slotboom is engaged in studying some peats from Luxembourg and Belgium (Haut-Fagne). W. Punt has begun a palynological study of the family Euphorbiaceae. It will take two years, and will be published as a dissertation. In connection with C. R. Jansen's work mentioned above, there will be an investigation of the Holocene history of the beech *(Fagus)* in the Netherlands.

University of Amsterdam

Professor Dr. J. Heimans, Director of the Hugo de Vries Laboratory Hortus Botanicus, reports the following activities in the palynological field: J. J. Wensink, of the Laboratory of Physical Geography, and B. Zwart have published a paper entitled "De jong-pleistocene en holocene ontwikkeling van een deel van Westergoo" [The late Pleistocene and Holocene history of a part of Westergoo (Province of Friesland)] (Geol. en Mijnb., no. 20, pp. 73–87, 1958). Mrs. W. Groenman-van Waateringe has published "Zandwerven; Monsters van donkere humeuze laagjes uit een profiel met bewoningsresten uit het Neolithicum," in: J. van Regteren-Altena, "Nieuwe opgravingen van de neolithische nederzetting te Zandwer-

ven, gem. Spanbroek" (Westfriesche Oudheden, vol. 1, pp. 8–23, 1958). Mrs. Groenman-van Waateringe has five manuscripts in press concerning palynological investigations of tumuli in the Netherlands, which will soon be published in "Brevia praehistoria." Miss M. R. Walvius has completed a manuscript on peat samples from the Island of Marken in the former Zuyderzee, and has reported on a boreal *Pinus* wood in Flevoland, at the edge of the former Zuyderzee.

Professor Dr. H. J. MacGillavry, of the Geological Institute, is now investigating *Lepidorbitoides* from the Maestrichtian type locality of St. Pietersberg, near Maastricht. Because of the importance of this type section, I shall quote below what he wrote to me:

"Our previous study on the evolution of *Lepidorbitoides* was based on samples collected at various separate localities. We are now studying the section collected by B. Romein from the quarry wall in the Pietersberg, Maastricht, which may be considered as a type section for the Maestrichtian. The various groups of fossils from this section are being studied by different specialists united in the commission for the study of the Maestrichtian, instituted for this purpose. We have here a consecutive suite of *Lepidorbitoides* populations, affording a valuable and rigorous check on the usefulness of the method.

"In order to obtain statistically valid results, half of each sample has been washed. The other half is retained as reserve material, so that others may check our results. The residue from the washed half is halved again by pouring it over a ruler with a triangular cross section, so that no sorting will occur as a result of the pouring process; thus, each part will be representative of the whole. One half of the residue is retained for a statistical check on any new feature to be found during our investigations. From theo ther half, the larger foraminifera have been picked out quantitatively. The specimens of each population are numbered, and lots are drawn to obtain a representative sample to be sectioned. Each specimen to be sectioned is first measured and described. A mimeographed list of all characters to be measured and described is filled in for each specimen. The sectioning is now in progress. The original plan to make a photographic record of each specimen before it was sectioned has had to be abandoned because of lack of suitable apparatus."

Geological Bureau of the Netherlands Coal Mining District, Heerlen

Dr. S. J. Dijkstra, in charge of the Paleobotanical Section, has published the following paper: "On a megaspore-bearing lycopod strobilus" (Acta Bot. Neerl., vol. 7, 1958, pp. 217–222, 4 pls.). In this publication an attempt was made to determine whether or not certain genera of megaspores correspond to certain fructifications of the Lycopodiales. Together with Mr. Piérart, Dr. Dijkstra has also published "Lower Carboniferous megaspores from the Moscow Basin" (Netherlands, Geol. Stichting, Meded., new ser., no. 11, 1958, pp. 20–33, 20 pls., 1 text-fig.).

Mr. Piérart, in collaboration with Dr. Dijkstra, will present a paper at the Carboniferous Congress in Heerlen, on megaspores from the Congo (Gondwana). These spores are so similar to those described by Dr. Dijkstra from Brazil (1955, Netherlands, Geol. Stichting, Meded., new ser., no. 9, pp. 5–10) that one would believe that they were from the same locality.

Geological Survey of the Netherlands

At the Paleobotanical Laboratory, where W. H. Zagwijn is in charge, extensive studies have been carried out on the pollen stratigraphy of the Dutch Holocene, as a tool for mapping purposes. Many of the radiocarbon datings made at the Groningen Laboratory have now been correlated with pollen diagrams. Research has continued on the stratigraphy of the Upper Pleistocene (Eemian and Weichselian), especially with regard to vegetational development at Amersfoort, as well as in connection with C^{14} dates. The results will be published during 1959. The results of studies on Pliocene and early Pleistocene vegetation are now being prepared for publication by Mr. Zagwijn, and will also be published during 1959. A study of the pollen floras of the pre-Pliocene Tertiary has been started.

From August, 1957, until September, 1958, A. van der Werff's diatom research was directed especially toward the Dollart, resulting in a report on the benthal species present in the Eems River, the Dollart itself, and the estuary of the Old Western Eems. The influence of salinity was investigated in connection with the impoverishment of diatoms in certain zones. The influence of alternating brackish and fresh water was also shown by diatoms in an investigation of a soil-sample collection from the neighborhood of Pagliacetto and Bosco Sacro in Italy.

Littoral-pelagic diatoms found in soil samples from an elevation of about 1600 meters in the neighborhood of Toba Lake, Sumatra, indicated the possibility that this lake formerly attained a much higher level. Diatoms found in archaeologic pottery specimens provided information concerning the environments in which the clay materials employed by the pottery occurred. Boreal diatoms present in soil samples indicated the probability of a colder climate in the northern part of the Netherlands during a certain period of time.

Publication of the "Dutch Diatom Flora" began in November, 1957. Each species is illustrated, usually in different views, by H. Huls, and is described on the same sheet by A. van der Werff. The individual sheets are to be combined into charts, each of which will contain the descriptions of fifty species and varieties. Besides these, about ten sheets with morphologic definitions and exact original drawings are appended. Eight to ten charts will be issued in a span of about five years; they will contain the illustrations and descriptions of about 600 species and varieties. The second

chart appeared in September, 1958. The charts are available by sending Hfl. 4.90 ($1.30) to:

A. van der Werff
Stationstraat 60
Abcoude (Netherlands)

Mr. van der Werff is publishing this "Flora" on a non-profit basis.

Your correspondent has recently published: "Les foraminifères Mio-Pliocènes et Quaternaires du Kruisschans" [near Antwerp] (Inst. Roy. Sci. Nat. Belgique, Mém., no. 142, 1958); and "Foraminiferen aus dem Eemien (Riss-Würm-Interglazial) in der Bohrung Amersfoort I (locus typicus)" (Netherlands, Geol. Stichting, Meded., new ser., no. 11, pp. 27–42, 4 pls., 1958).

We are pleased to announce that the results of the ecological and sedimentary petrological study of the Eems estuary will be published in 1959. The manuscripts of the several collaborators are now ready, and will be published in the "Verhandelingen van het Geologisch Mijnbouwkundig Genootschap." The expected titles of the various contributions are as follows: Professor Dr. P. H. Kuenen: "Allgemeine Einleitung"; Dr. J. H. van Voorthuysen: "Tektonische Vorgeschichte"; Mej. S. Jelgersma and Ir. de Smet: "Holozäne Geschichte"; Dr. R. Dorrestein: 1) "On the distribution of salinity and some other properties of the water in the Eems estuary," and 2) "On the mixing and flushing of the water in the Eems estuary"; Dr. H. Postma: "Chemische Untersuchung des Meerwassers"; Dr. A. J. Wiggers: "Die granulometrische Zusammensetzung der holozänen Sedimenten im Dollart-Emsästuar"; Dr. R. D. Crommelin: "A contribution to the sedimentary petrology of the Dollart as compared with adjoining areas"; Dr. J. C. L. Favejee: "Röntgenologische Untersuchung der Tone im Ems-Dollart-Ästuar"; J. H. Stock and de Voss: "Die wirbellosen Tiere des Dollart-Ems-Ästuar"; Dr. C. W. Wagner: "Ostracoden-Biocoenosen und Thanatocoenosen im Ems-Ästuar"; A. van der Werff: "Die Diatomeen des Dollart-Emsgebietes"; Dr. J. H. van Voorthuysen: "Die Foraminiferen des Ems-Dollart-Ästuar"; Dr. S. van der Heide: "Einige Bemerkungen zur Mollusken-Fauna des Dollart-Emsgebietes"; and Professor Dr. P. H. Kuenen Dr. R. Dorrestein, and Dr. A. J. Wiggers: "Allgemeine Schlußfolgerungen."

The laboratory of Dr. Jan Hofker
The Hague

A long manuscript dealing with all the Cretaceous sediments younger than the Hervian (middle Campanian) has been completed and sent to press. The Campanian-Maestrichtian boundary has been established by means of foraminifera at many localities in south Limburg. Above the Tuff Chalk and the Kunrade Chalk, in the northern part of the area, lowermost Paleocene and the entire Montian have been found. As in the type locality at Mons, the Montian consists of two formations, the Tuffeau de Ciply and the Calcaire grossier of Mons. Extensive sampling in the basin of Mons has produced very clear indications of the correlation of the chalks there with those of south Limburg. Overlying the Montian, Thanetian beds were discovered. Many preliminary notes on foraminifera from these Upper Cretaceous and lower Tertiary formations have already been published (Natuurhist. Maandblad, 1955–1958).

A study has also been made of core samples from a boring near Glons, in Belgium, penetrating the Upper Cretaceous through the Hervian. A range chart and diagrams showing the phylogenetic changes in many species, together with brief descriptions and figures of these species of foraminifera, were published in 1958 (Soc. Belge Géol., Mém.).

A paper on the foraminifera of the *Streblus* group from the upper Tertiary of Kruisschans, near Antwerp, Belgium, has been published (Inst. Roy. Sci. Nat. Belgique, Mém., no. 142, 1958). A series of short papers, all dealing with the analysis of type species of foraminifera in an attempt to establish their taxonomic positions, has begun to appear in the Contributions from the Cushman Foundation.

An analysis of the foraminifera of the type localities of the Santonian, Campanian, and Dordonian (Maestrichtian) in the northern Aquitaine Basin has nearly been completed. It will be published in the reports of the Cretaceous Colloquium to be held at Dijon in April, 1959.

A study of a large suite of samples of Recent foraminifera collected by Dr. Hiltermann from the Bay of Naples has been finished. This paper will be published in collaboration with Dr. Hiltermann, who will deal with the ecology of these faunas.

Short papers are in press, or have already been published, on the evolutionary series *Bolivinoides decorata – australis – gigantea* in Belgium, on Reiss' ideas concerning the Bilamellidea, and on the globigeriniform genera recently established by Loeblich and others. The analysis of the foraminifera of the Oligocene of Ecuador (Part 3 of the series) will be ready during 1959; the work is progressing steadily.

J. H. van Voorthuysen
Geological Survey of the Netherlands
Haarlem

GERMANY

HEINRICH HILTERMANN

The curricula of German universities and technical schools are now

putting greater emphasis on micropaleontology. It has become an independent subject, comprising a series of lectures and laboratory problems which are conducted at the various schools by the following personnel: Munich, H. Beckmann and H. Hagn; Braunschweig, F. Bettenstaedt; Berlin, H. Diebel, Klaus J. Müller, and F. Thiergart; Hamburg, F. Hecht; Göttingen, H. Hiltermann; Halle a. S., H. W. Matthes; Jena, Arno Müller; and Greifswald, Gerda Wehrli-Olbertz.

It is noteworthy that the Technical University in Berlin has established a special lectureship (Diätendozentur) for applied micropaleontology, which is now held by Klaus J. Müller.

In my annual report entitled "Bibliography of micropaleontology in Germany for 1958," which will be published in an early issue of this quarterly, about 100 publications are cited. These papers are mainly stratigraphically oriented. They comprise all types of animal and plant microfossils. They are distributed stratigraphically as follows: Paleozoic, 14; Triassic, 3; Jurassic, 11; Cretaceous, 9; Tertiary, 38; and Quaternary, 8 publications. Many of these reports contain only lists of microfossil names. Thirty publications, however, give descriptions and illustrations, and involve taxionomic problems. About one-third are devoted to microbotany, specifically palynology.

A detailed review of methods and techniques in various fields of micropaleontology was published in a separate book, Part 3 of Volume 2 of the "Handbuch der Mikroskopie in der Technik" (Umschau Verlag, Frankfurt a. M., 1958), by H. Freund. The 500 pages, in fourteen chapters, of the book are concerned with the significance, representation, and stratigraphic use of animal and plant microfossils. After a brief historical introduction containing thirty-six portraits of micropaleontologists, most of which have not been published before, H. Hiltermann and H. Beckmann outline, systematically, the methods of collecting and isolating fossils and examining them. H. Bartenstein writes on their significance in the petroleum industry. Then E. Triebel writes an excellent introductory note on his photomicrographic methods. Special sections on work in microzoology are as follows: H. Hiltermann, foraminifera; E. Triebel, ostracodes; Hertha Sievers-Doreck, echinoderms; and W. Weiler, otoliths. The charophytes, described by K. Mädler, are treated in the beginning of the microbotanical chapters, in which F. Overbeck devotes considerable space to analysis of Quaternary pollen. These chapters are followed by special sections on the palynology of the Tertiary, by U. Rein, and of the Carboniferous, by H. Potonié. Finally, F. Hustedt discusses the preparation and examination of diatoms.

Another important new publication is Vladimir Pokorný's book "Grundzüge der zoologischen Mikropaläontologie," which is a greatly improved and augmented German translation of the manual published in Czech by Pokorný in 1954. The first volume, recently published by the Akademie Verlag, Berlin, with 582 pages and 549 text-figures, concerns only the Protozoa. After a general introduction, one chapter is devoted to each of the following main groups of animals: Radiolaria, Thecamoeba, Foraminifera, Tintinnina, Incertae sedis (Pithonella, Stomiosphaera, Cadosina, Oligostegina, etc.), Chitinozoa, and Hystrichosphaera. The morphology, taxonomy, and ecology of each animal group is discussed. The principal emphasis is on the foraminifera.

The new book by A. Remane and C. Schlieper entitled "Die Biologie des Brackwassers" deals in great detail with problems of brackish-water ecology. It was published by Schweizerbart (Stuttgart) as volume 22 of the series "Die Binnengewässer." The authors attempted to bring out the most important ecologic and physiological characteristics of this particular biotope which lies between marine and fresh water. The water bodies discussed are the Baltic Sea and the three extended Pontocaspian brackish seas, the Black Sea, the Caspian Sea, and the Aral Sea.

A description of the conodonts of the Mediterranean Triassic has been published by R. Huckried in volume 32 of the Paläontologische Zeitschrift. Five tables contain the descriptions and vertical ranges of forty species.

The discovery by A. Rieth that an agglutinating species of foraminifera is living in brackish inland waters of Thuringia is of considerable scientific interest. It was reported in a brief publication in volume 47 of "Mikrokosmos".

Ten micropaleontologists, mainly from the oil industry, accepted the invitation to the "Colloquie Internazionale de Micropaleontologia in Italia." A one-week field trip was conducted to the classic localities, some of which have been known in the literature for 100 years. We visited, among other places, Asti, Castel Arquato, Tortona, S. Marino, Bottacione, and the wonderful section in the mountainous massif of Maiella (Abbruzze). The trip was extremely well organized. All participants returned home with a large volume of samples and were very much impressed by the beauty of the countryside and the towns dating from the Middle Ages. May I avail myself of this opportunity to express my thanks to our Italian colleagues for their warm reception and manifold kindnesses. Special thanks are due to the members of the Instituto di Geologia of Milan University.

As in preceding years, the Amt für Bodenforschung at Hannover has had a number of visitors from foreign countries, who have studied our work, methods, or material. The visitors during the past year were: F. Allemann, of Teheran; A. Bassiouni, of Cairo; W. Berggren, of Stockholm; J. Bradshaw, of La Jolla, California; Dorothy Echols, of St. Louis; R. Gandolfi, of Rome; Mme Garrot, of Paris; A. Gianotti, of Rome; G. Gry, of Charlottenlund, Denmark; Mohsenul Haque,

of Quetta, Pakistan; Yousset Khoury, of Damascus; T. Ørvig, of Stockholm; A. Reyment, of Stockholm; and L. Saldanha, of Lisbon.

The annual meeting of the Paläontologische Gesellschaft, held at Aachen August 25–29, was highly successful with regard to interchange and discussion of results of micropaleontological research. In addition to the presentations of papers, at the Mining Department of the Technische Hochschule, Professor K. Rode organized some excellent field trips to important localities, where samples could be collected. We also express our thanks here to our Belgian and Dutch colleagues, especially B. J. Romein, who showed us the type locality of the Maestrichtian, as well as other important outcrops of the Upper Cretaceous. Papers on micropaleontology constituted a large number of the twenty-six presented. The authors and titles are listed below:

H. Fiebig: "Development and fauna of the Aegir horizon of the Lipper main trough"; S. Geroch: "Stratigraphic significance of arenaceous foraminifera in the Carpathian Flysch"; H. Hiltermann: "Stratigraphically important foraminifera in the Cretaceous of Aachen"; J. Hofker: "Foraminifera of the Upper Cretaceous of the Glons boring in northeastern Belgium"; W. Krutzsch: "Spores and pollen of the Senonian at Aachen"; K. Mädler: "Taxonomy of the Hystrichospherids"; H. Pflug: "Primary and secondary coal occurrences in the Cretaceous at Aachen"; R. Potonié: "Ecology of Carboniferous plant associations"; A. Voges: "Conodonts and other fossils from the Kulm siliceous slates"; and E. Voigt: "The paleoecological significance of 'hard ground' in the seas of the Upper Cretaceous.

This meeting was a great success, as nearly all of the more than 100 participants knew one another personally, a friendly atmosphere prevailed, and a large number of colleagues from other countries took an active part in the discussion.

Micropaleontological topics were also included in the programs of other meetings. For example, at the 110th general meeting of the Deutsche Geologische Gesellschaft, which took place at Marburg/Lahn, September 1–9, W. Ziegler spoke on "The Middle Devonian/Upper Devonian boundary as established on conodonts." In addition, papers read by F. Gramann, on faunal problems and by H. D. Lang on palynological problems of the Niederhessische Senke were based particularly on micropaleontology.

At the meeting of the Oberrheinischer Geologischer Verein, held at Regensburg, April 8–12, F. Oschman spoke on the stratigraphy of the Regensburg Cretaceous, and J. H. Ziegler reported on micropaleontological research in the Cretaceous of the Oberpfalz. At the meeting of the Geologische Gesellschaft of the D.D.R. (East Germany), held at Stralsund, April 24–27, the following micropaleontological papers were presented: G. Alberti: "Microplankton of the Mesozoic and Cenozoic"; W. Krutzsch: "Paleogeography of the Central European Lower Tertiary"; Gerda Wehrli-Olbertz: "Foraminifera of the Upper Cretaceous of Rügen"; and Eva Weinholz: "Micropaleontological results from wells through the Liassic of Mecklenburg."

At the monthly meetings of the Deutsche Geologische Gesellschaft, lectures on micropaleontological topics were presented as follows: O. Bischoff, in Hannover, and H. Dengler, in Wiesbaden: "Application of conodonts in the stratigraphy of the Paleozoic"; G. Lüttig, in Hannover: "The Plio-Pleistocene of central Italy" (limnic ostracodes play an important role in the stratigraphy of this region); H. D. Pflug, in Wiesbaden: "Palynological investigations in Hessen"; and A. Rabien, in Wiesbaden: "Stratigraphy and facies in the Paleozoic of the Dill trough" (with reference to ostracodes).

HEINRICH HILTERMANN
Amt für Bodenforschung
Hannover

SPAIN

GUILLERMO COLOM

Micropaleontological activities in Spain have increased considerably during the past year. The "Compañía Española de Petróleos," "Adaro", and other Spanish and foreign companies, with both foreign and Spanish personnel, are actively engaged in exploring the national territory for possible deposits of hydrocarbons. In addition to this, a certain amount of private research is being carried on, as in former years, by foreign geologists and micropaleontologists, some of whom (R. Ciry, P. Rat, J. Sigal, and J. Magné, among others) have published interesting notes on the stratigraphy of the Mesozoic and Tertiary of Spain in recent years.

All of this activity has resulted in the discovery of interesting groups of foraminifera and other microfossils in the northeastern part of the Iberian Peninsula (Burgos, Santander, Navarre, etc.), in the Ebro Valley, and in Andalusia. Greater precision in our knowledge of the stratigraphic levels of these regions is continually being obtained, but much of this work is still unpublished. A recent publication is J. P. Mangin's study entitled "Note préliminaire sur les 'calcaires à Alvéolines et Nummulites' du versant Sud des Pyrénées" (C. R. Acad. Sci., Paris, vol. 246, 1958).

Franz Kockel has found, for the first time in Spain, an abundant fauna of conodonts in the Paleozoic of Malaga, better known to Spanish geologists as the "Bético de Malaga" ("Conodonten aus dem Paläozoi-

cum von Malaga, Spanien," Neues Jahrb. Geol. Pal., Monatshefte, 1958, pp. 255-262). The long lists of species found in each of the deposits indicate that they are of Wenlock and Ludlow ages.

With the publication of her thesis ("Estudio de los microforaminíferos miocenicos del Aljarafe (Sevilla)," R. Soc. Española Hist. Nat., Bol., vol. 55, no. 5, 1958, pp. 131-186), Srta. Trinidad del Pan has given us our first knowledge of the vertical and regional distribution of numerous species in the province of Seville. Stratigraphic charts of the distribution of species, as well as sections of the deposits, illustrate this paper. This work will enhance our knowledge of these species and their chronological value in the Miocene formations of southern Spain.

Your correspondent, after many years of work on the Jurassic and Cretaceous pelagic sediments deposited throughout the Betic-Balearic geosynclines, believes that he has succeeded in demonstrating (Soc. Géol. France, Bull., ser. 6, vol. 7, 1957 (1958). fasc. 9, pp. 1167-1187), that the fine gray marly limestones known in Italy and other Mediterranean countries as "majolica" and "biancone" represent the purest facies of the pelagic sediments of those periods. They are sediments formed far from all continental influence, and they also, at times, represent undoubted bathyal deposits of considerable depth, according to the place that they occupied within the area of the geosyncline. These findings appear to confirm the idea of the "leptogeosyncline" set forth by Trümpy in 1957, that is to say, geosynclines with very fine pelagic sediments, free from terrigenous influences and also characterized by the slight thickness of their beds. The Upper Jurassic and Lower Cretaceous of the Balearics (Iviza-Majorca) together do not attain a total thickness of 100 meters. The enormous duration of these periods must be taken into consideration. Their macrofaunas consist solely of ammonites of pelagic facies, typical of the area of the Mediterranean Tethys. This is contrary to the classic concept of the geosyncline, at least as it was first expounded by Hall and Dana, in which beds of great thickness, as well as strongly influenced by detrital contributions, were assumed to have been deposited.

Srta. Menendez Amor, head of the palynological laboratory of the Museo de Ciencias Naturales, Madrid, is continuing to work on pollen and spores, especially those of the Pliocene and Quaternary of the Iberian Peninsula. Extensive collections have been made from fossil peat bogs, former lakes that are now filled in, and similar environments. These collections are being studied with special reference to the paleoclimatology of these two periods.

Srta. M. C. Bonet is continuing her studies of the Carboniferous spores of Spain. Together with S. J. Dijkstra, of the Netherlands, she has published a paper on Carboniferous megaspores from La Camocha, Spain (Estud. Geol., Madrid, vol. 12). Other studies are in preparation.

GUILLERMO COLOM
Soller, Mallorca

UNITED STATES - EAST COAST

RAYMOND C. DOUGLASS

Smithsonian Institution (U. S. National Museum)

Richard S. Boardman reports that he is working on two manuscripts: One is a restudy of the type species of the trepostomatous bryozoan genera *Trematopora*, *Batostoma*, and *Anaphragma*; the other is the description of the rhomboporoid Bryozoa of the Hamilton group of New York State. Mr. Boardman has just returned from a collecting trip in the Middle Ordovician of the Central Basin of Tennessee and the Southern Appalachians. This trip initiated a continuing study of the bryozoans of those areas. He was accompanied on the trip by Miss June Phillips, of Sydney, Australia, and by Dr. Nils Spjeldnaes, of the University of Oslo, Norway, both of whom are students of Lower Paleozoic Bryozoa.

The following students of foraminifera visited the National Museum during 1958: Esther R. Applin, U. S. Geological Survey, Jackson, Mississippi; Horacio H. Camacho, Argentine Geological Survey, Buenos Aires; W. A. Gordon, College of Agriculture and Mechanical Arts, Mayaguez, Puerto Rico; Shoshiro Hanzawa, Tohoku University, Sendai, Japan; A. F. M. Mohsenul Haque, Pakistan Geological Survey, Quetta; Hartono, Indonesian Geological Survey, Bandung; James J. Jones, University of Wisconsin, Madison; and Priscilla J. Militante, University of the Philippines, Quezon City.

U. S. Geological Survey Washington, D. C.

Miss Ruth Todd reports that she has the following studies in progress: 1) An ecologic study of foraminifera from Recent sediments of Onotoa, in the Gilbert Islands; 2) (with Miss Doris Low) Recent foraminifera from shallow water around the island of Martha's Vineyard, Massachusetts; 3) (with Miss Doris Low) an ecologic study of foraminifera from the Bahama Banks and Florida Straits; 4) (with N. M. Perlmutter) Upper Cretaceous foraminifera from wells along the south shore of Long Island; 5) Recent and Tertiary smaller foraminifera of Guam; and 6) deep-sea cores from off the Marshall Islands. In addition, the following papers by Miss

Todd are in press: "Foraminifera from western Mediterranean deep-sea cores"; (with Miss Doris Low) "Smaller foraminifera from Eniwetok drill holes"; and (with Paul D. Blackmon) "Mineralogy of some foraminifera as related to their classification and ecology."

A paper entitled "Pennsylvanian-Permian boundary in north-central Texas," by Lloyd G. Henbest, was published by the San Angelo Geological Society in their Guidebook for 1958 (pp. 38–49). Mr. Henbest also participated in the field conference on "The base of the Permian – a century of controversy," as a guest of the San Angelo Geological Society. Papers on the "Geologic and ecologic significance of the Upper Paleozoic foraminifera in the Hartville area, Wyoming," and on the "Significance of karst terrane and residuum in Upper Mississippian and Lower Pennsylvanian rocks, Rocky Mountain region," were published by Mr. Henbest in the Guidebook for 1958 of the Wyoming Geological Association.

The October issue of the Contributions from the Cushman Foundation contains an article by Mr. Henbest on the "Ecology and life association of fossil algae and foraminifera in a Pennsylvanian limestone, McAlester, Oklahoma." In the limestone described, sessile foraminifera are preserved in their original attachment to marine algae of a previously undescribed group. A description of the algae is being published by Sergius H. Mamay, of the U. S. Geological Survey.

I. G. Sohn reports that his "Revision of the Upper Paleozoic ostracode genera; Part 1: The Paleozoic species of *Bairdia* and related genera" is in press. He presented an oral paper on *Bairdia* at the St. Louis meetings of the Geological Society of America. Part 2 of his "Revision," on *Aechminella*, *Amphissites*, and related genera, has been completed and is awaiting publication. His present studies include additions to his "Revision," a study of Tertiary marine ostracodes from Pakistan, Cretaceous ostracodes from Israel, Lower Cretaceous ostracodes from the Black Hills of South Dakota, and ostracodes from the Green River beds of Colorado and Wyoming.

Wilbert Hass reports that he is continuing his studies of the stratigraphic ranges of significant conodont genera and species in the North American standard Middle and Upper Devonian succession of western and west-central New York and Pennsylvania. A preliminary paper entitled "Upper Devonian conodonts of New York, Pennsylvania, and interior states" was published in the July, 1958, issue of the Journal of Paleontology. The paper on "Conodonts of the Chappel limestone of Texas" is to be published as U. S. Geological Survey Prof. Paper 294–J, and is now in galley proof. This paper includes a classification of disjunct conodonts.

Raymond Douglass has completed a paper entitled "Revision of the family Orbitolinidae," to be submitted to MICROPALEONTOLOGY. Publication of this study will have to be delayed, however, until the names used in his study of the genus *Orbitolina* are made available by publication in U. S. Geological Prof. Paper 333. He is now studying several hundred collections of Pennsylvanian and Permian fusulines obtained in eastern Nevada and western Utah during the 1958 field season.

McLean Paleontological Laboratory
Alexandria, Virginia

The death of Colonel James D. McLean, U. S. Marine Corps, Retired, on February 27, 1958, has materially decreased the scientific activities of the laboratory. Colonel McLean acted as a silent partner in the work of the laboratory ever since its start in 1950, and handled well over half the activities of the laboratory, leaving the Director free to undertake scientific research. The work has now been restricted to the task of keeping the card catalogues of Foraminifera, Ostracoda, and holothurian sclerites on schedule.

Several attempts on the part of interested students to come under the training program of the laboratory during the past several months failed for lack of financial support for the would-be trainees. There has been regret over the loss of these possible trainees, but the laboratory, as a non-subsidized institution, is unable to advance funds for trainees. Any trainee accepted must bear his own living expenses and must pay for the training.

University of North Carolina

Charles W. Copeland, Jr., is preparing a systematic and paleoecological paper on the foraminifera of the Upper Miocene Duplin marl and immediately underlying beds at two localities in Duplin County, North Carolina. Mr. Copeland has completed all of his collections and has nearly finished the sedimentary analysis work for the paleoecological part of the paper. He has found well preserved material containing a number of interesting genera and species.

Marcus B. Morehead is just beginning a Ph.D. dissertation on the distribution of Recent foraminifera from Core Sound, the southern end of Pamlico Sound, and the Neuse River estuary in eastern North Carolina. The area includes a wide range of physical conditions of inland waters, ranging from nearly fresh water to water of normal marine salinity, from turbulent to very slow-moving water, and from well to poorly oxygenated water. If it is feasible, Mr. Morehead also plans to collect Recent pelagic, benthonic, and planktonic foraminifera from the outer banks beyond Core Sound for comparative purposes. The project is in the planning stage at present.

Joseph St. Jean, Jr., is continuing work on Middle Devonian Stromatoporoidea from southern Ontario, and is comparing the faunas with those found in Europe, especially with those of the Eifel region in Germany. All of the sectioning and most of the preliminary identifications have been made.

The course in micropaleontology at the University of North Carolina has been expanded to a full year. The first semester comprises the

study of pollen and spores, conodonts, ostracodes, and minor fossil Protozoa, and an introduction to the foraminifera. The second semester is devoted to the foraminifera.

Princeton University

Richard Olsson has completed a study of foraminiferal faunas at the Cretaceous-Tertiary boundary in New Jersey. His doctoral dissertation, on this subject, was completed last spring. The paleontological portion of the work has been submitted to the Journal of Paleontology, and the stratigraphic results are being readied for submittal to the A.A.P.G.

Henry Ohlen, a graduate student at Princeton, is making a paleoecological study of a Triassic (Rhaetian) reef complex in the eastern Alps (Kammerköhr region). Thin sections of the various facies have revealed a considerable foraminiferal fauna, which shows ecologic variations and which is quite distinct from the succeeding Liassic fauna.

Yale University

Professor Carl O. Dunbar has begun work on fusulines from the Carboniferous and early Permian of Greenland. Charles Ross' study of the type Wolfcamp and its microfauna is well advanced, and is scheduled for completion in 1959. Thomas E. Williams has begun a study of the fusulines of the Waco limestone in the Waco Mountains, El Paso and Hudspeth Counties, Texas.

In the field of smaller foraminifera, Don Eicher's work on the micropaleontology and stratigraphy of the Thermopolis shale (Lower Cretaceous) has been completed. His manuscript is being processed for publication in the Peabody Museum Bulletin series.

Completion of a new laboratory, primarily for the preparation of thin sections, has considerably increased the productive capacity, and will facilitate work on the larger foraminifera. This laboratory, installed during the summer of 1958, was opened in October.

The AMERICAN JOURNAL OF SCIENCE announces the establishment of a RADIOCARBON SUPPLEMENT to be devoted wholly or largely to publication of radiocarbon date lists from laboratories in various parts of the world. Professors Richard Foster Flint and Edward S. Deevey, Jr. are the editors. The office of the SUPPLEMENT is the same as that of the AMERICAN JOURNAL OF SCIENCE: Box 1905A, Yale Station, New Haven, Connecticut, U.S.A.

Volume 1 of the SUPPLEMENT will appear in May 1959. Thereafter, one volume will appear each year. The SUPPLEMENT will be separate from the AMERICAN JOURNAL OF SCIENCE and will be sent to a separate subscription list. The price of Volume 1 has been set at $2.50.

Cornell University

Professor W. Storrs Cole reports the following studies:

1) For the U. S. Geological Survey, he has completed a study of the larger foraminifera of Guam Island and Yap, and is working on the larger foraminifera of Ishigaki. His paper on the larger foraminifera of the Eniwetok drill holes has been published.

2) Other studies include a paper completed, on a revision of the subgenus *Proporocyclina*, soon to be published in the Bulletins of American Paleontology, and a completed manuscript on *Asterocyclina* from a pebble dredged in French Oceania, soon to be published by the Cushman Foundation.

Norman Sacks is continuing his study of American species of the genus *Lepidocyclina*. Dr. Shoshiro Hanzawa, of Tohoku University, Sendai, Japan, spent the fall semester of 1958 as a University Fellow at Cornell under a Fulbright Grant.

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

William D. Athearn reports that, as planned last year, some coring was carried on from the *Atlantis* in the Cariaco Trench, off northern Venezuela. It is planned to return to that area again, for a more general sediment survey of the continental shelf area between eastern Venezuela and Panama, including some work in the Gulf of Venezuela and in Lake Maracaibo. About twenty long cores were taken last year, and Mr. Athearn has been working on the gross stratigraphy of some of them. He has done no detailed work as yet, but he has observed many planktonic foraminifera, mostly orbulinids, sometimes so concentrated (within zones a centimeter or so in thickness) as to warrant calling the material a globigerina ooze, in spite of the fact that the area is a basin within the limits of the continental shelf and only a short distance from land. In some places the sediments, which are definitely terrestrial, also contain large numbers of pteropods, particularly of what is probably the genus *Creseis*. On the next cruise Mr. Athearn intends to collect and preserve samples for a study of living foraminiferal populations from about 200 stations throughout the area of study.

Brown University

Richard Cifelli reports that he has completed his study of the Bathonian foraminifera of Great Britain, which has been submitted to Harvard University as a Ph.D. thesis. It is now being prepared for publication. He is also studying two closely spaced cores from the North Atlantic, and attempting to correlate them by means of foraminifera. The cores were collected from a single station at the same time, from two points only 8 feet apart.

Daniel J. Stanley has completed his M.A. thesis, on the Lower Tertiary foraminifera of the Vidoño shale member of the Santa Anita formation in eastern Venezuela. Mr. Stanley is now studying at the Institut Français du Pétrole, Paris.

New York University

Several new research projects were instituted at the Department of Geology during the past year, while a number of projects previously undertaken were completed. Harold L. Cousminer is nearing the final

stages of his study of polymorphism as found in various living and fossil foraminiferal populations. David D. Hughes is continuing his study of the Cyrenaican Coast of northern Libya. Richard A. Grossman has undertaken a study of the "microforaminiferal" element in selected fossil foraminiferal faunas, and Richard Charmatz has completed a paper on the foraminiferal fauna of Eniwetok Atoll, in collaboration with Dr. H. I. Hirshfield, of the Department of Biology. Edwin F. Beemer is attempting to recover spores and pollen from the Kootenai formation of central Montana, under the sponsorship of the Montana Bureau of Mines and Geology. Foster Smith has completed his course work and all examinations for the doctorate except for the defense of his dissertation.

Gilbert J. Brenner has completed his zoogeographic study of the Gulf of California, tracing the northern limits of tropical Panamic foraminifera. Josephine Sperazza has completed her biostratigraphic study of Cretaceous and Tertiary foraminifera from Sicily. Darwin O. Hemer's correlation of the Rub' al Khali section with that of Dammam, both in Saudi Arabia, and Feodor Bourgeois' study of plant microfossils from the same country, have been successfully terminated. Jerome Brock has concluded his study of shallow- and brackish-water foraminifera of Tampa Bay, Florida.

Dr. Shoshiro Hanzawa has joined the faculty of the Department of Geology for the 1959 spring semester, and is lecturing on larger foraminifera. A second new course, in photogeology, has been instituted during this semester. Beginning with the fall semester of 1959, Noel K. Brown, of the Gulf Oil Corporation, will take over the course in larger foraminifera, expanding it to a full year of study.

American Museum of Natural History

The Department of Micropaleontology's long-term study of "microforaminifera," which was initiated under a grant from the Jersey Production Research Company, has been completed.

The *Sea Owl*, a 100-foot research vessel that is being used as a floating laboratory in a Departmental study of the sediments and micro-organisms of Long Island Sound, has been in operation since July, 1957. A substantial number of cores from the Sound, as well as additional data relative to the area, have been secured. The equipment used was, for the most part, designed by Dr. Ellis. The foraminiferal element of the cores is now under study by Richard Charmatz.

Hans J. Behm and Edmund F. Grekulinski have collaborated on a paper dealing with the ecology of Recent brackish-water foraminifera from Staten Island, New York. This paper was published in the Proceedings of the Staten Island Institute of Arts and Sciences (vol. 20, no. 2, pp. 53–66, 1 pl., 1958).

One of the major activities of the Department during 1958 was the completion of a microfilm edition of the CATALOGUE OF FORAMINIFERA. This edition makes it possible for a great many more universities, colleges, surveys, and oil companies to secure a copy of this basic reference set. Two additional volumes each of the CATALOGUE OF FORAMINIFERA and the CATALOGUE OF OSTRACODA were completed during 1958.

On February 15th, Dr. E. S. Salmon, Assistant Curator and long-time member of the Department of Micropaleontology, resigned to accept a position in the Central Abstracting Service of the A. P. I. Her work there will deal primarily with publications in the Russian language.

Miss Caroline Turco and Mr. Richard Charmatz are now serving as Research Assistants in the Department of Micropaleontology where they are carrying on the work formerly done by Dr. Salmon.

During 1958, the following micropaleontologists were among the many visitors to the Department: Arthur N. Dusenbury, Jr., Shoshiro Hanzawa, David D. Hughes, Betty Kellett Nadeau, Krishna Mohan, Robert Morris, I. G. Sohn, R. M. Stainforth, Lawrence Weiss, and Stanley Wissler. A. F. M. Mohsenul Haque, of the Geological Survey of Pakistan, spent several weeks at the Department studying foraminifera and consulting reference works.

RAYMOND C. DOUGLASS
U. S. Geological Survey
Washington, D. C.